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(71) Applicant: **Pressac Interconnect Limited
Long Eaton, Nottingham NG10 1FW (GB)**

(72) Inventors:

- **Astill, John Thomas
Borrowash, Derby DE72 3LY (GB)**
- **Swift, Michael Philip
Long Eaton, Nottingham NG10 1PP (GB)**

(74) Representative: **Powell, Timothy John
Eric Potter Clarkson,
Park View House,
58 The Ropewalk
Nottingham NG1 5DD (GB)**

(54) **Mirror and method of making the same**

(57) A mirror comprising a reflective mirror substrate having a front surface which is intended to be viewed in use and a rear surface, and heating means including a

layer or layers of electrically conductive and/or resistive materials applied directly to the rear surface of the substrate.

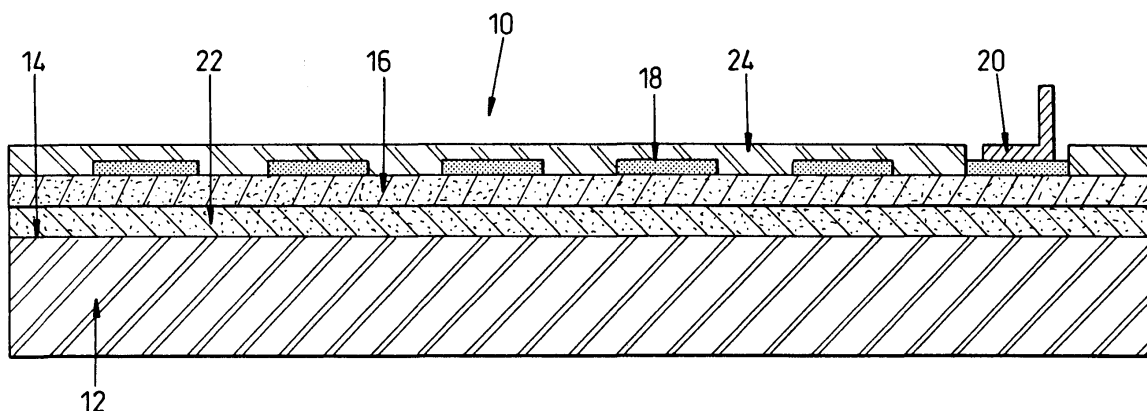


Fig. 1

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Description

[0001] This invention is concerned with a mirror, especially a heatable mirror suitable for use as a rear view mirror in motor vehicles, and a method of making the same.

[0002] Heatable rear view mirrors for use in motor vehicles are known and are especially useful in adverse weather conditions for de-misting or de-icing external rear view mirrors.

[0003] One method which is currently used in the production of heatable mirrors is to procure a relatively thin flexible substrate, for example a polyimide or polyester film, and provide a pattern of conductors on the surface of the polyester film. The conductors may provide a constant wattage heating element. Connectors to supply electricity to the conductors are preferably also attached to the pattern of conductors at an appropriate point. The thus formed flexible printed circuit is then adhered to a rear surface of the mirror substrate by means of a suitable adhesive.

[0004] Mirrors made in this way have proved to be reasonably satisfactory but there are problems associated with this type of mirror. For example, in order to produce a heatable mirror it is first of all necessary to make the flexible printed circuits and then necessary to attach the flexible circuit to the mirror substrate by adhesive: this assembly operation is manual, time-consuming and therefore costly. Furthermore, the flexible circuit is separated from the mirror substrate which needs to be heated at least by a layer of adhesive and, normally, by the flexible substrate of the printed circuit both of which will usually provide significant heat insulation. It is necessary to transmit the heat generated by the electrical circuit through at least the adhesive layer, and usually through the flexible substrate of the printed circuit before the mirror substrate itself is heated: this gives a significant "warm-up" time to the mirror assembly and requires power which will be consumed in heating the flexible substrate and the adhesive layer rather than the mirror substrate itself which it is designed to heat.

[0005] One of the various objects of the present invention is to provide an improved heatable mirror.

[0006] In one aspect the invention may be considered to provide a mirror comprising a reflective mirror substrate having a front surface which is intended to be viewed in use and a rear surface, and heating means including a layer or layers of electrically conductive or resistive material applied directly to one surface of the substrate wherein at least one layer is in the form of a pattern of electrical conductors.

[0007] In a mirror in accordance with the invention, the layer is conveniently in the form of a pattern of electrical conductors. This pattern of electrical conductors may conveniently provide a constant wattage resistance heating element or a pattern may be formed which when utilised with a material which provides a positive tem-

perature coefficient resistive material may provide a controlled temperature heating element.

[0008] A mirror in accordance with the invention may also comprise temperature monitoring and control circuitry.

[0009] A mirror in accordance with the invention may be made from any suitable material, for example glass, but the invention is applicable to other mirror substrates, for example polymer or film-based mirrors. The reflective surface of the mirror may be on either the front or rear surface of the mirror base substrate and may be provided by a layer of a suitable reflective material applied to either surface of the mirror. Dependent on the mirror substrate material and the reflective surface material, if any, in a mirror in accordance with the invention an electrically insulating layer may need to be applied to the rear surface of the mirror prior to application of the layer or layers of electrically conductive or resistive material. Where an electrically insulating layer is applied to the substrate in carrying out a method in accordance with the invention, the material of the insulating layer is preferably selected to facilitate adhesion of the applied electrically conductive or resistive layer to the insulating layer.

[0010] If desired, an electrically insulating sealing layer may also be applied over the conductive or resistive layer or layers to provide added protection. Vehicle mirrors desirably have anti-shatter characteristics which is especially important where the mirror substrate is of glass: any electrically insulating sealing layer which may be applied to the mirror over the conductive or resistive layer or layers is preferably such as to also provide an anti-shatter layer; a suitable layer may be an electrically insulating polymeric material. An electrically insulating sealing layer can be applied by any convenient method including printing, contact coating for example by a roller, spraying, or laminating. An electrically insulating sealing layer not only provides electrical insulation but also provides environmental protection, eg against ingress of moisture, to the electrical circuitry.

[0011] A mirror in accordance with the invention conveniently also requires connecting means for making an electrical connection to the heating means. Any convenient connecting means may be used and these include the soldering of connectors, terminals or electrically conductive cable directly to the electrically conductive layer (which may be treated, if necessary, to facilitate soldering). Connectors, terminals or cables may also be secured to the electrically conductive layer by a suitable electrically conductive polymer based adhesive. Mechanical connecting means, for example including contactors spring-loaded into engagement with contact region of the electrically conductive layer may also be used. Such spring-loaded contactors may be mounted in separate housings in a final mirror assembly or may be moulded into a mirror support eg a backplate of the mirror assembly, to which the mirror is secured eg by a suitable adhesive layer.

[0012] In another aspect the invention may be considered to provide a mirror assembly comprising a mirror comprising a reflective mirror substrate having a front surface which is intended to be viewed in use and a rear surface, heating means including a layer or layers of electrically conductive or resistive material applied directly to one surface of the substrate wherein at least one layer is in the form of a pattern of electrical conductors, and a mirror support on which the mirror is mounted.

[0013] Conveniently the mirror support may mount resilient contact means adapted to make electrical connection with contact regions of the layer of electrically conductive material on the rear surface of the mirror substrate. Alternatively, electrical connection may be made to the electrically conductive layer by means of a connector assembly generally as described in our Patent Application Serial No. 2303975.

[0014] In yet another aspect the invention may be considered to provide a method of making a mirror including heating means comprising applying a layer or layers of electrically conductive or resistive material provided by a pattern defining electrical conductors or resistors directly to one surface of a reflective mirror substrate, the front surface of which is intended to be viewed, to provide said heating means, and applying an insulating layer to the said surface of the mirror substrate before applying said layer or layers of conductive or resistive material.

[0015] Conveniently in carrying out a method in accordance with the invention the layer of electrically conductive or resistive material is applied in the form of a pattern defining electrical conductors and/or resistors. The pattern may be applied by any suitable means. For example, the layer may be applied by printing a conductive ink comprising a polymer loaded with a conductive powder, onto the rear surface of the mirror substrate. Alternatively, the layer may be applied by printing a polymer capable of metallisation onto the rear surface and metallising the polymer layer in a desired pattern. Other known techniques of providing electrically conductive or resistive elements onto the surface of a substrate may conveniently be used. For example, the layer may be applied by a process selected from electroless plating of a conductive material, vacuum depositing of conductive material, and moulding of a support housing incorporating heating means, to the rear surface. Various methods may be utilised to define the pattern of electrically conductive or resistive tracks which may include spraying a suitably conductive ink through a stencil or, application of a continuous layer of conductive material followed by removal of selected parts of the material to provide conductive tracks, the removal being achieved by any suitable technique, for example by use of a laser or by photo-imaging techniques.

[0016] In one method in accordance with the invention conductive tracks may be printed of resistive material to provide resistive heating; a further layer of more con-

ductive material may be printed in a suitable pattern to provide electrical connection to the resistive tracks at appropriate points.

[0017] In another method in accordance with the invention a first layer may be printed in a PTC material and a further layer of conductive material may be printed in a suitable pattern to provide electrical connection to the PTC layer at appropriate points.

[0018] A mirror in accordance with the invention is conveniently made by a process in accordance with the invention.

[0019] There now follows a detailed description to be read with reference to the accompanying drawings of heatable mirrors embodying the invention and methods of making the mirrors. It will be realised that these mirrors and their methods of manufacture have been selected for description to illustrate the invention by way of example.

[0020] In the accompanying drawings:-

Figure 1 is a diagrammatic view in section of a first mirror embodying the invention;

Figure 2 is a diagrammatic view in section of a second mirror embodying the invention;

Figure 3 is a diagrammatic view in section of a third mirror embodying the invention;

Figure 4 is a diagrammatic view of a fourth mirror, similar to the third illustrative mirror but also including surface mounted components;

Figure 5 is a diagrammatic view of a fifth mirror similar to the fourth mirror but with a combined terminal and surface mounted component;

Figure 6 is a diagrammatic view of a sixth mirror similar to the second mirror but with a combined terminal and surface mounted component;

Figure 7 is a view of a seventh illustrative mirror similar to the second illustrative mirror but with a surface mounted component;

Figures 8 and 9 are plan views each showing a pattern of conductors suitable for use in the first, second, sixth and seventh illustrative mirror; and

Figure 10 is a plan view showing a single continuous conductor suitable for use in the third, fourth and fifth illustrative mirrors.

[0021] In the drawings like numbers are used to indicate like parts.

[0022] The first illustrative mirror 10 comprises a reflective mirror substrate 12 provided by a glass sheet with a reflective coating of known material on a rear surface 14 thereof. In Figure 1, the front surface is shown facing downwardly and the rear surface 14 facing upwardly which is a suitable orientation for manufacture of the first illustrative mirror. The mirror substrate has a layer 16 of uniform thickness of electrically conductive material namely a positive temperature coefficient resistive material (PTC material) applied to the rear surface 14. To the layer 16 are applied a series of electrically con-

ductive tracks 18 configured to provide an electrical power supply to the PTC layer which provides a resistive heating element. PTC heating elements are known to those skilled in the art.

[0023] The first illustrative mirror further comprises connecting means 20 for connecting an electrical supply to the pattern of conductive tracks 18 so that an electrical current can be passed through the conductive tracks 18 to the PTC layer 16 whereby to provide resistive heating of the mirror. An electrically insulating layer 22 of a suitable polymeric material is applied over the top of the layer (not shown) of reflective material (which is commonly metallic and electrically conductive) on the rear surface 14 of the mirror substrate thus to electrically insulate the PTC layer from the reflective coating. The layer 22 is sufficiently thin and heat conductive to not significantly restrict transfer of heat from layer 16 to the mirror substrate and may assist in providing an anti-shatter coating for the mirror. Any suitable electrically insulating material may be used eg an acrylic or epoxy based material.

[0024] An electrically insulating sealing layer 24 is applied over the conductive tracks 18 and the PTC layer 16 at the rear surface 14 of the substrate 12. The layer 24 provides electrical insulation for the circuitry and an environmental seal preventing contamination of the electrical circuitry by dirt or water. The layer 24 is also chosen to provide a shatter resistant coating for the mirror which minimises the risk of glass fragments being forcibly ejected if the mirror substrate is broken. As can be seen viewing Figure 1, the connecting means 20 extends through an opening in the layer 24. The layer 24 may be any suitable polymeric insulating material eg an insulating ink supplied under the name Coats UV600 which is believed to be an acrylic based material.

[0025] In the manufacture of the first illustrative mirror, in carrying out a method embodying the invention, the conductive tracks 18 are applied by screen printing an electrically conductive ink onto PTC layer 16 (provided as a continuous coating) on the rear surface of the mirror substrate.

[0026] In carrying out a method embodying the invention of making the first illustrative mirror any suitable conductive printing ink may be used to print conductive tracks and suitable inks include polymer based inks including conductive particles, for example silver, or particles which can be converted into a conductive material. The conductive material is applied to the PTC layer 16 by screen printing or other suitable techniques to provide conductive tracks 18 in the desired orientation. The ink may be treated to provide a surface layer rich in conductive material, facilitating soldering to the conductive tracks 18 to provide electrical connection means. In another otherwise similar alternative method where the tracks 18 are not suitable for soldered joints contact pads of solderable material may be applied to the tracks 18 at appropriate positions.

[0027] Connecting wires may be soldered directly to

the conductive tracks 18 or a suitable connector or terminal 20 may be secured to the conductive tracks. Alternatively, a connector assembly substantially as described in our Patent Application GB2303975 may be used to provide resilient connection means with the first connector member described therein secured to the mirror substrate on which the pattern of conductive tracks is applied, so that the first connector member is in a pre-selected orientation relative to conductors of the printed circuit.

[0028] The insulating layer 22, the PTC layer 16 and the sealing layer 24 may also be applied by screen printing, if desired, or they may be applied by any other suitable means for example by other coating techniques. It is, however, especially important to control the thickness of the PTC layer carefully to ensure satisfactory heating performance: ideally, the PTC layer 16 should be uniformly thick throughout its area.

[0029] The first illustrative mirror may be assembled with a plastics moulded mirror support to provide a first vehicle mirror assembly. The mirror support may be constructed to accurately locate the mirror relative to the support so that resilient contact means generally similar to the contact means shown in our Patent Application No. 2303975 may be used to make electrical connection with contact regions of the conductive tracks 18. The mirror is adhered to the support by an adhesive layer to provide the mirror assembly (but may be secured to the support in any convenient manner in a mirror assembly otherwise similar to the first illustrative mirror assembly). The adhesive layer may be applied to either the support or the mirror (or both) prior to assembly, as required by the user. The adhesive layer may provide the main anti-shatter layer, or contribute to the anti-shatter properties of the mirror assembly in cooperation with layers of the mirror itself.

[0030] A second illustrative mirror, shown in Figure 2 is generally similar to the first illustrative mirror except that the conductive tracks 18 are printed directly onto the insulating layer 22. The PTC layer 16 is then applied over the pattern of conductive tracks 18 but leaving a sufficient opening for the terminal 20 to be secured.

[0031] In the first and second illustrative mirrors at least two separate conductive tracks 18a, 18b are required and these are preferably arranged to cover substantially all of the area of the PTC layer 16. The tracks 18a, 18b, are spaced equally apart to provide a uniform heating effect and conveniently may follow a tortuous path as shown in Figure 8 or be provided by interdigitated conductive fingers as shown in Figure 9. Each conductive track 18a, 18b has a connecting means 20a, 20b applied thereto.

[0032] A third illustrative mirror, see Figure 3, includes a constant wattage resistive heater and comprises a substrate 12 carrying an electrically insulating layer 22 on its rear surface 14. A layer of resistive material is applied to the insulating layer 22 as a conductive track 18 with connecting means 20 in an appropriate position. A

sealing layer 24 is applied over the conductive track 18.

[0033] The track 18 of the third illustrative mirror is printed in the same manner as the tracks of the first and second illustrative mirrors but the ink is selected to have a resistivity appropriate to provide a required amount of resistive heating from the track 18. The track 18 is positioned to provide a desired heating performance for example uniform heating over the area of the mirror. A suitable tortuous path for a single conductive track 18 covering the whole mirror area to be heated is shown in Figure 10 with connecting means 20 for making an electrical connection to the track at either end.

[0034] A fourth illustrative heater is similar to the third illustrative heater except that it also includes a surface mounted circuit component 26 comprising a chip 28 encapsulated in a suitable potting compound. The component 26 extends between two of the tracks and may by suitable design, perform any required function: for example it may monitor the temperature of the mirror and include control circuitry controlling the current flow through the tracks 18 to maintain the temperature of the mirror within a required range, an LED, or electrical circuitry for any other desired purpose.

[0035] A fifth illustrative mirror (Figure 5) is the same as the fourth except that the connecting means 20 is connected to the chip 28 of the surface mounted component 26, instead of directly to a conductive track 18.

[0036] A sixth illustrative mirror is similar to the second illustrative mirror except that it also includes a surface mounted component 26, including a chip 28, and the connecting means 20 is connected to the chip 28. In this case, too, the component 26 may include control or monitoring circuits and may also include an LED (light emitting diode) to indicate that the heated mirror is operational, or for illumination purposes, or electrical circuitry for any other desired purpose.

[0037] A seventh illustrative mirror (Figure 7) is similar to the sixth mirror except that the connecting means 20 is applied directly to one of the tracks 18 rather than to the surface mounted component 26.

[0038] Where the reflective surface of a mirror is provided by a layer of reflective material on the front of the substrate 12, it may not be necessary to utilise an electrically insulating layer adjacent the substrate 12 and thus the layer 22 may be omitted in that case.

[0039] Whereas the PTC layer 16 in the first, second, sixth and seventh illustrative mirrors is a continuous layer, the PTC layer may be discontinuous. For example a suitable pattern of PTC material may be deposited on the substrate 12. The pattern is preferably chosen to provide desired heating characteristics whilst minimising expense (the PTC material has a significant cost). Clearly the pattern chosen must be appropriate. One pattern which may be suitable is a pattern of parallel stripes 30 of PTC material (for example, as shown diagrammatically in dash-line on Figures 8 and 9). As can be seen the stripes 30 extend transversely of lengthwise runs of the conductive tracks 18a, 18b, each stripe 30

making electrical contact with the conductive tracks 18a, 18b which it crosses.

[0040] In comparison with known heatable vehicle mirrors the illustrative mirrors have a reduced number of components; for example there is no separately applied adhesive layer nor any flexible printed support film included. Because there are a fewer number of components, assembly time and costs are reduced and manual assembly operation can be eliminated. Because the conductive tracks are closely adjacent the mirror substrate, heating is more efficient than with the previously known systems requiring less power to heat a given surface area and a reduction in time to achieve effective heating when compared with the previous systems.

Claims

1. A mirror comprising a reflective mirror substrate having a front surface which is intended to be viewed in use and a rear surface, and heating means including a layer or layers of electrically conductive or resistive material applied directly to one surface of the substrate wherein at least one layer is in the form of a pattern of electrical conductors.
2. A mirror according to Claim 1 wherein the pattern provides a constant wattage resistive heating element.
3. A mirror according to either one of Claims 1 and 2 comprising temperature monitoring and control circuitry.
4. A mirror according to Claim 1 wherein one of the layers is a layer of positive temperature coefficient (PTC) material which is applied to said one surface of the mirror substrate to provide a heating element in electrical contact with said pattern of electrical conductors which provides an electrical supply to the PTC layer.
5. A mirror according to Claim 4 wherein the layer of PTC material is provided by a discontinuous pattern.
6. A mirror according to Claim 4 wherein the layer of PTC material is provided by an array of parallel spaced stripes.
7. A mirror according to any one of the preceding claims comprising a sealing layer applied to said one surface of the mirror substrate to which the heating means is applied, to provide electrical insulation and an environmental seal which initiates against ingress of dirt or moisture to the conductive tracks.

8. A mirror according to Claim 7 wherein the sealing layer also provides an anti-shatter layer.
9. A mirror according to any one of the preceding claims wherein an insulating layer is applied to said one surface before the layer or layers of conductive or resistive material.
10. A mirror according to any one of the preceding claims further comprising connecting means for making an electrical connection to the layer or layers of conductive or resistive material.
11. A mirror according to Claim 1 wherein the substrate comprises glass.
12. A mirror assembly comprising a mirror comprising a reflective mirror substrate having a front surface which is intended to be viewed in use and a rear surface, heating means including a layer or layers of electrically conductive or resistive material applied directly to one surface of the substrate wherein at least one layer is in the form of a pattern of electrical conductors, and a mirror support on which the mirror is mounted.
13. A mirror assembly according to Claim 12 wherein the mirror support mounts resilient contact means adapted to make electrical connection with contact regions of the layer of conductive material.
14. A method of making a mirror including heating means comprising applying a layer or layers of electrically conductive or resistive material provided by a pattern defining electrical conductors or resistors directly to one surface of a reflective mirror substrate, the front surface of which is intended to be viewed, to provide said heating means, and applying an insulating layer to the said surface of the mirror substrate before applying said layer or layers of conductive or resistive material.
15. A method according to Claim 14 wherein the pattern is provided by printing a conductive or resistive ink onto said one surface.
16. A method according to Claim 14 wherein the pattern is provided by printing a polymer capable of metalisation onto said one surface and metallising the polymer layer.
17. A method according to Claim 14 wherein the pattern is provided on said one surface by a process selected from electroless plating of a conductive material, vacuum deposition of conductive material and moulding of a support housing incorporating heating means to the rear surface.
18. A method according to Claim 14 wherein the pattern is provided by spraying an electrically conductive material onto said one surface.
19. A method according to any one of Claims 14 to 18 comprising securing an electrical connection to the pattern of electrical conductors.
20. A method according to any one of Claims 14 to 19 comprising applying a sealing layer over the pattern of conductors or resistors to provide an environmental seal.
21. A method according to any one of Claims 14 to 20 comprising applying a pattern of electrical conductors to the substrate and either before or after applying said pattern of conductors, applying a layer of positive temperature coefficient material to the substrate to be in electrical contact with said pattern of conductors and provide a heating element.
22. A method according to Claim 21 wherein the layer of positive temperature coefficient material is applied as a series of parallel stripes extending transversely to a lengthwise direction of said conductors.

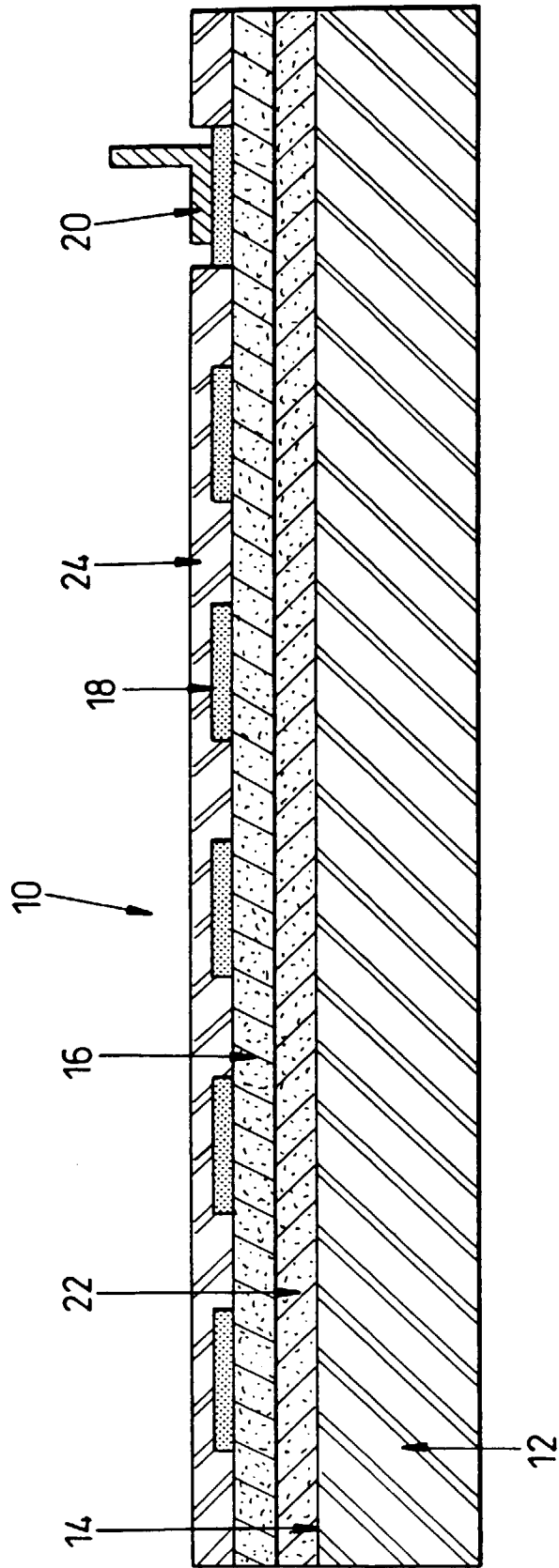


Fig. 1

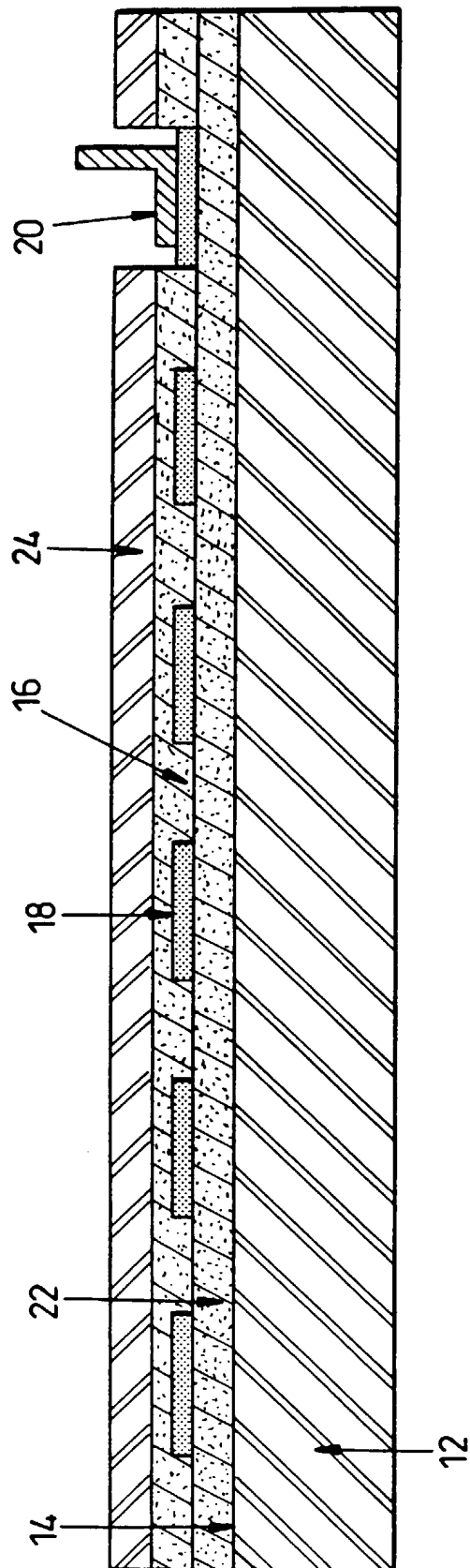


Fig. 2

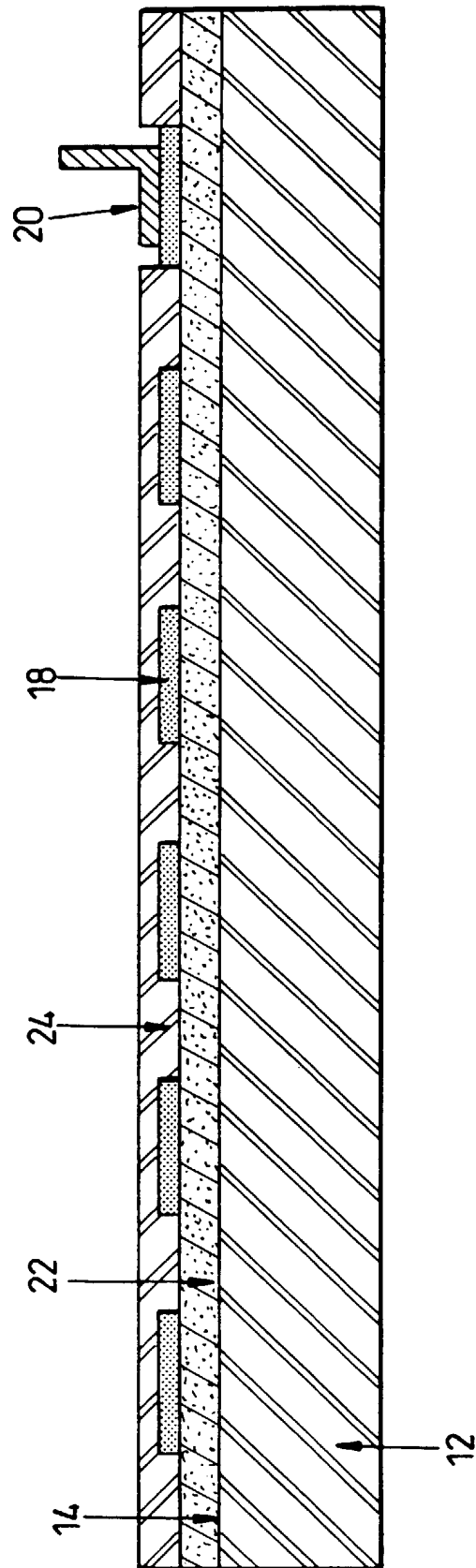


Fig. 3

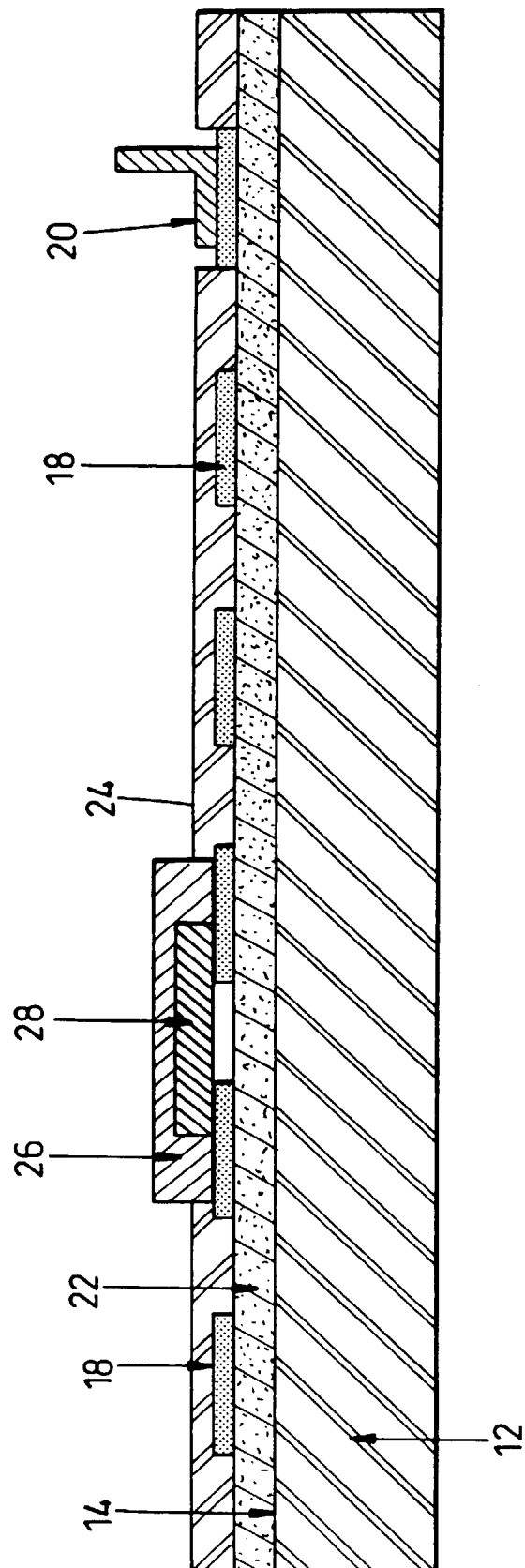


Fig. 4

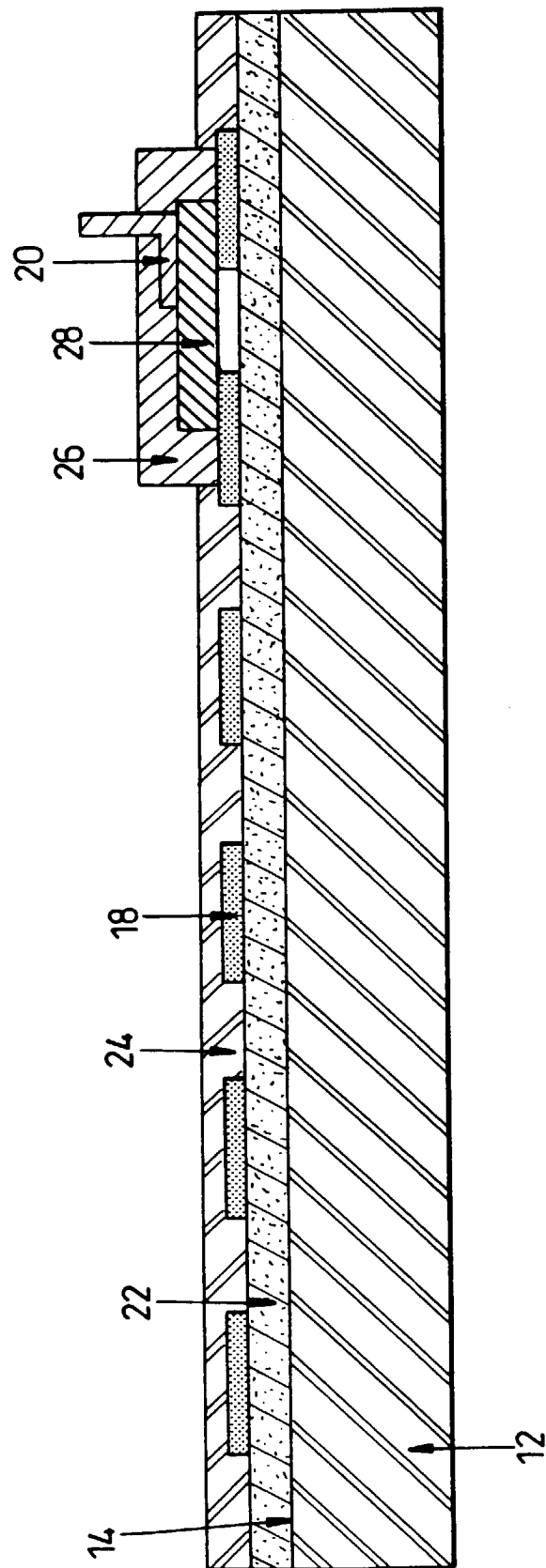


Fig. 5

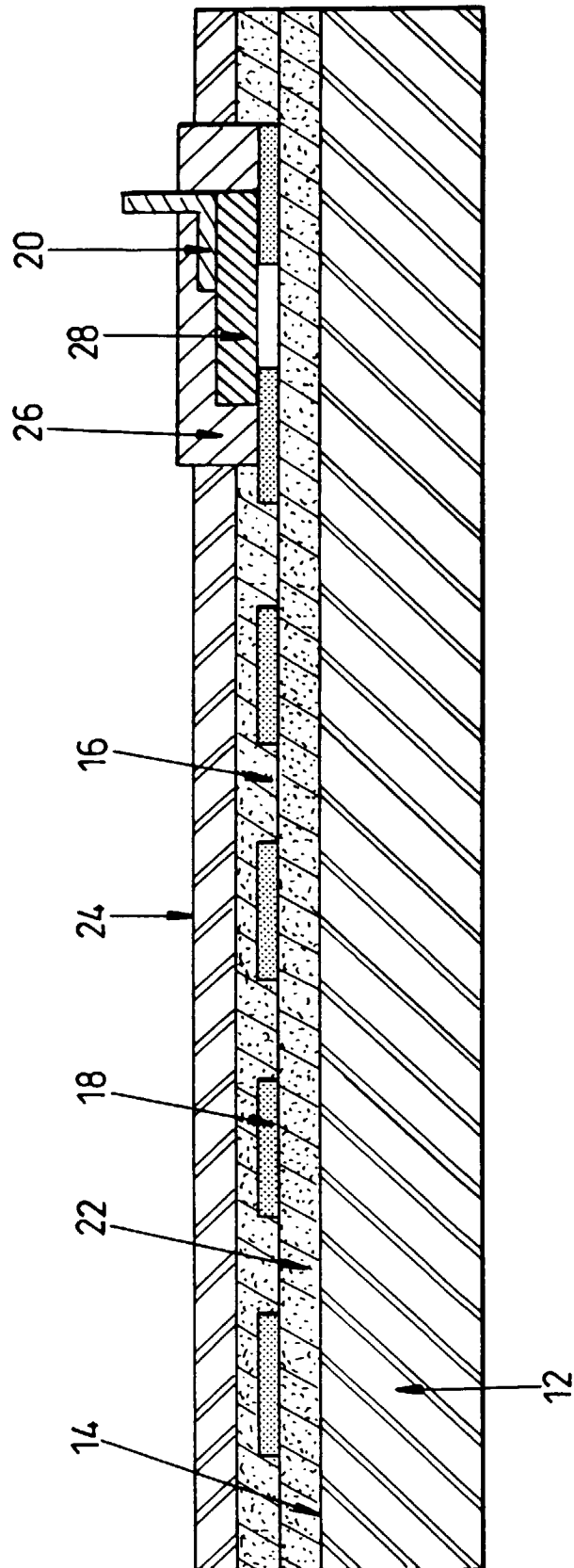


Fig. 6

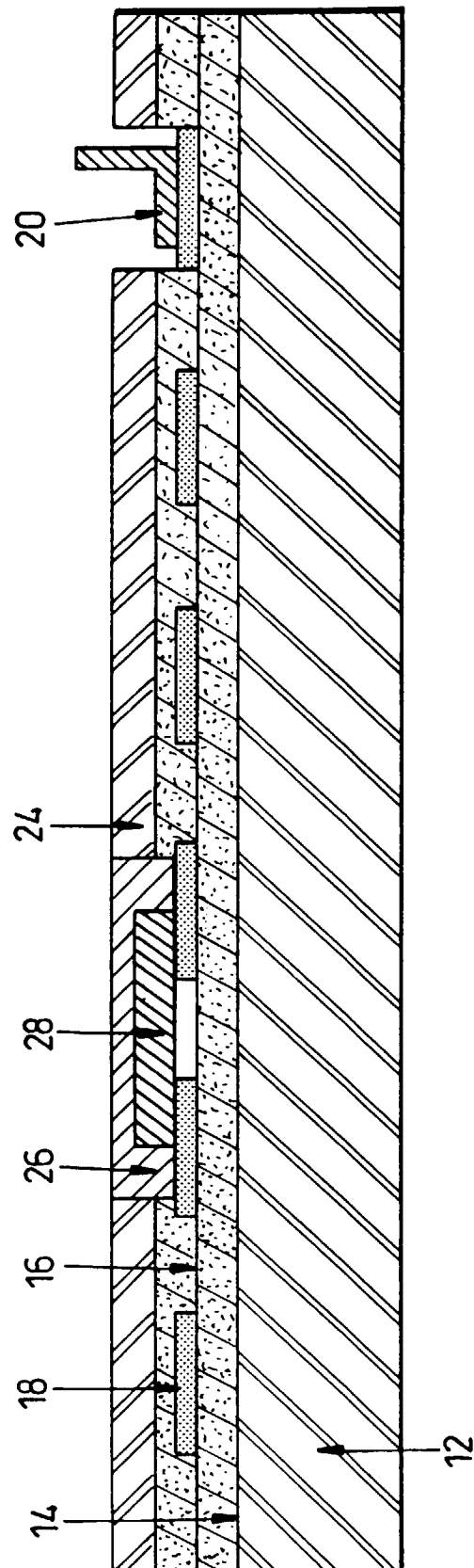


Fig. 7

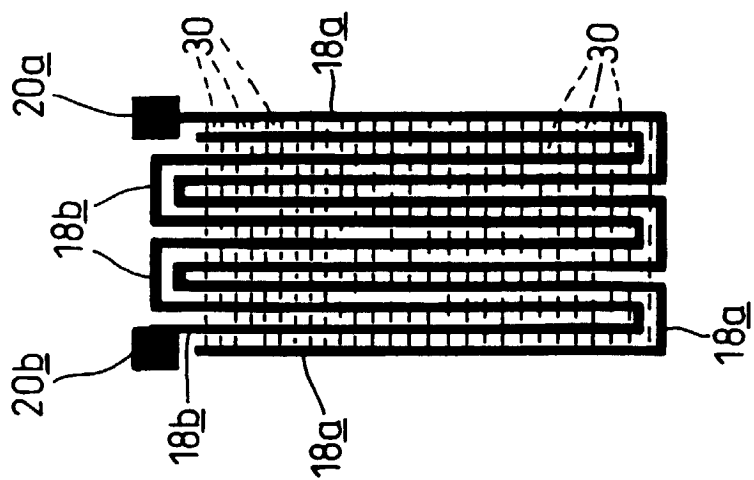


Fig. 8

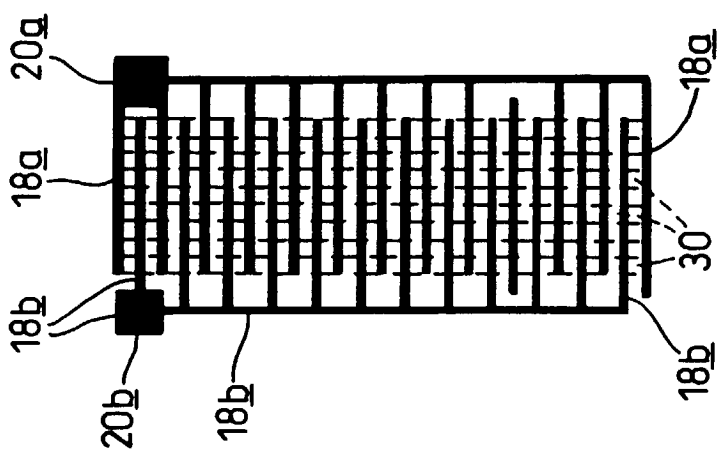


Fig. 9

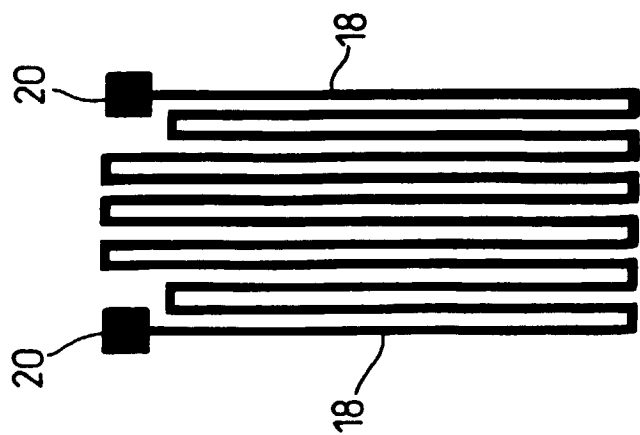


Fig. 10