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

(11) Publication number: 0 197 745
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 86302386.7

(22) Date of filing: 01.04.86

(51) Int. Cl.[4]: H 01 B 1/24

(30) Priority: 30.03.85 GB 8508411
21.05.85 GB 8512873
04.07.85 GB 8516995

(43) Date of publication of application:
15.10.86 Bulletin 86/42

(84) Designated Contracting States:
AT BE CH DE FR IT LI LU NL SE

(71) Applicant: Romaniec, Charles
57 Willis Street
Warrington(GB)

(72) Inventor: Romaniec, Charles
57 Willis Street
Warrington(GB)

(74) Representative: Lyons, Andrew John et al,
ROYSTONS 531 Tower Building Water Street
Liverpool L3 1BA(GB)

(54) **Conductive materials.**

(57) A conductive material comprises carbon/graphite particles dispersed in a polymer, such as polyacrylonitrile or polyurethane. The conductive material may be used to make heating tapes by coating a fabric, such as polyamide, therewith on both sides and providing energising conductors attached thereto.

EP 0 197 745 A1

Title: Conductive Materials

DESCRIPTION

This invention relates to conductive materials for use for example in the manufacture of protective screens, electrically heated fabric for tapes, panels, under-blankets, garments and for other purposes.

An object of the invention is to provide an effective and versatile conductive material which is relatively simple and inexpensive to manufacture and is capable of withstanding adverse conditions of use.

According to the invention therefore there is provided a conductive material comprising carbon/graphite particles dispersed within and held together by a body of, preferably water-soluble, aliphatic and/or aromatic polymer.

The polymer chosen may depend on the end use of the conductive material. For example, for uses in connection with a high voltage, such as used for mains electricity in the U. K., aliphatic polymers, such as polyacrylonitrile, are preferred. However, for uses in connection with a lower voltage, such as used for mains electricity in the U.S.A. or D.C., a polyurethane, particularly an aliphatic polyurethane is preferred.

With this material, desirable conductive and protective properties can be obtained in a particularly simple and convenient manner whilst at the same time it is possible to achieve good resistance to abrasion, to corrosive materials (such as acids and alkalis), and to moisture. Moreover the conductive and protective properties (particularly the electrical conductance or resistance) can be maintained generally constant (or at least can be maintained within an acceptance range) throughout a range of operating conditions (e.g. over a temperature range of say -40°C to 150°C).

Further, the material may have a high modulus of elasticity and good resistance to hydrolysis.

The polymer and the carbon/graphite (which may comprise the carbon material identified as Vulcan CX72R or Corax L6) may be uniformly mixed for example by a milling process to give a precursor dispersion.

Preferably the carbon/graphite particles comprise 12 to 55% of the solid polymer by weight. Additives, such as to enhance flame retardancy, may also be incorporated in the material. Examples of such additives are decabromodiphenyl oxide DE-83R at 20 to 40%, preferably 25 to 40%, by weight or antimony trioxide.

The precursor dispersion may be processed, to give the conductive material in the form of a flexible film or yarn or tape, and this may be in conjunction with any suitable substrate, supporting material or reinforcing material.

In a preferred process, the conductive material mixture is deposited at a suitable viscosity onto both sides of, or integrated into a suitable fabric. A preferred fabric is an aromatic polyamide fabric. The fabric preferably has desired properties, such as inflammability and flame resistance. Another suitable fabric is disclosed in U.S. Patent No. 4251589 and U.K. Patent No. 1593246. The resulting textile material obtained as explained above can be extremely stable to ultra violet rays, oxygen in general, and to heat and may have excellent resistance to water, solvents, mineral oils and grease.

The conductive material of the invention compares favourably with, for example, cupro-nickel wire as a heating medium since it does not produce a magnetic field and may be inflammable. The conductive material of the invention can be used in a variety of items as a heating medium. Examples of such items include therapeutic heating pads, domestic underblankets and heated mattresses, heated seats for motor vehicles, heated blankets for truck drivers and heated clothing. As can be seen some of the above will require mains electricity and others battery power. The conductive material of the invention can be used for both electricity sources subject to the provision of a suitable interface.

The conductive fabric of the invention may be constructed to give a square law circuit having a closed path for the electrical energy in which the current functions equally and uniformly due to the ohmic resistance within the heated fabric.

Moreover, due to the "excitation state", a higher than normal heat energy distribution over frequencies extending into the far infra red at low and ultra low levels can be obtained. This arises due to the energising source (electric current) passing through molecules of the carbon particles.

Also, basic fabric can be chosen to have no fire hazard or wettability, and so be an ideal medium for the conductive material to form an infra red (far) energy emitter for far infra red radiation (wavelength of the order of microns).

Typical mechanical properties for the basic fabric may be as follows:

100% modules (kg/cm^2) at	45% carbon CX72R blended at 25% to 50%
Loading	=96
300% modulus (kg/cm^2)	=200
Tensile strength (kg/cm^2)	=Longitudinal 7.5
	Latitudinal 6.5

Elongation %	=average 150
Embrittlement (°C)	= -40 to -45
Loss of flexibility (°C)	= -35
Hardness (Shore A)	= 88
Film thickness	= 0.08 mm average

Exploiting electrical conductivity/resistance to pass electrical currents, for example in safe, reliable heating whether either directly or indirectly via an associated storage material, such as sodium sulphate crystals $Na_2SO_4 \cdot 10H_2O$ say for warming-pads. These can be used by people, e.g. divers, pilots, oil rig or building industry personnel, simply to combat cold, or more generally for therapeutic purposes.

The area and space between electrodes which transfer the supply of electrical energy over the heating area is approximately four to twelve inches apart. The electrical energy flow between adjacent electrodes occurs only through the conductive field of resistive material comprising woven or non-woven film in between the electrodes.

In order to ensure good electrical (OHM) resistance, preferably to be coated over the fabric of this conductive substrate for a volume of quality at the dry stage per square metre is about 150 grammes. Where the fabric of construction requires warp/weft 295DTXZ530XS530 weave warp/weft 12.8 ends/picks per cm. Weight 160 grammes/square metre further to ensure a full bonding integration of the conductive polymer to be applied on both sides of fabric.

According to another aspect of this invention there is provided a heating tape comprising a textile fabric base or core tape impregnated and/or intimately coated with a carbon-containing synthetic polymer material that is electrically conductive.

Preferred heating tapes hereof are capable of being energised at satisfactorily high electrical resistance when driven by mains A.C. electricity and the frequency of oscillation causes the electrical energy to be distributed over the whole length of the tape.

One such feature relates to the difficulty using tape of only about 25 mm width of achieving adequate electrical resistance if energising conductors are applied simply at sides of the tape as then, only the width of the tape contributes to electrical resistance and is too short for the primary purposes hereof. Accordingly, it is proposed that areas of the conductive material be used to develop the required electrical resistance, and to do so using selective insulation of conductors from conductive material at either, preferably both, faces of the tape and effective selective inter-connection of feed and return conductors relative to such areas. Advantageously, edge-adjacent runs of conductors, which may be tinsel, are electrically insulated from the carbon-containing material, and excursions of such conductors across the tape are made to define said areas, then with conduction through the carbon material thereof from excursions of the feed conductor to excursions of the return conductor, i.e. along the length of the tape rather than across its width and with overall electrical resistance for a particular carbon containing material then set by the spacings of said excursions. Electrical supply can be connected simply to each end of the conductors.

Heating tapes hereof are quite simple to manufacture, as will become clear from later description of specific implementation, and can afford substantially uniform electrical characteristics per unit area of the tape. Additionally, the possibility presents itself of the heating tapes being controlled with a substantial degree of self-regulation/limitation arising from the fact that the electrical resistance of the carbon containing polymer material can be temperature-dependent, i.e. it will consume and convert to heat less electrical energy at higher temperatures, and such action can be correlated to achieving a desired temperature of whatever is heated by the tapes hereof.

This invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows schematically production of conductive fabric;

Figure 2 shows one form of heating tape and its parts in a selective diagrammatic manner as sections through the tape;

Figure 3 shows a second form of heating tape;

Figure 4 shows a part section through the tape of Figure 3;

Figure 5 shows a third form of heating tape; and

Figure 6 is a longitudinal section through the tape of Figure 5.

Referring to Figure 1, in the production of conductive fabric, polyamide fabric 10 travels from a main roller 12 over rollers 14, 15 to pass beneath a hopper 16 from which a coating of a mixture comprising carbon particles in an aliphatic polymer, such as polyacrylonitrile, is deposited onto one side of the fabric 10. A scraper 18 controls the depth of mixture on the fabric. The coated fabric then travels through an extraction zone 19, wherein solvent, probably water, is drawn off by heating to facilitate drying of the coating. The fabric then leaves the extraction zone 19 and travels over a pair of rollers 20, 21 so that the uncoated side thereof is uppermost. This side is then coated with a mixture comprising carbon particles in polyacrylonitrile from a hopper 22. A scraper 24 regulates the depth of coating on the fabric. The fabric is then returned to the extraction zone 19 for further removal of solvent. After leaving the extraction zone 19, the fabric passes through an air cooler 26 and then is wound onto a final roller 28.

The fabric produced by this process can be used in a variety of ways such as in making the heated tapes described below. Thus referring to Figure 2, there is a core layer 32 of narrow (say 25 mm) elongate (say 100 metres), textile fabric for which polyamide fabric is suitable. Surfaces of the fabric tape 32 are then coated with electrically conductive carbon-containing polymer material, which may lie thereon as surface coatings 34A, 34B in mutual juncture via filled interstices of the fabric core tape 30.

The cured electrically conductive coatings 34A, 34B have attached thereto at edge-adjacent positions parallel lengthwise strips of insulating tape material 36A, 36B, such as of pvc or silicone rubber, say by ultrasonic welding. Those insulating strips 36A, 36B are shown to layers 34A, 34B at opposite sides of the tape 32 so as to rely on conduction/resistance through the thickness of the tape 32. Electrical conductors 38A, 38B, which it is preferred be of tinsel, are then laid along the insulating strips 36A, 36B with side extensions 40A, 40B at intervals corresponding to twice the intended lengths of the electrically conducting areas to be defined, the extensions 40A, 40B to each side being shown staggered into a symmetrical intercalation pattern for such definition, conveniently relative to area lengths of about 40 centimetres. As shown, such comb-like conductor formations 38A, 40A and 38B, 40B are readily formed from flexible tinsel conductors that are taken out across the width of the tape and back at the aforesaid intervals.

The purpose of the conductor extensions/loops 40A, 40B in their comb-like relation to feed and return conductors 38A, 38B along each edge of the overall tape, normally for live and neutral of mains electrical supply, is to utilise regions of the conductive material of the tape between those extensions 40A, 40B for primary electrical conduction along the lengths of the areas of those regions in order to give the required power dissipation/heat generation for the overall tape so as to get about 10-12 watts per metre, as would apply for resistances of 5000 ohms and currents of 0.04 amps at 220 volts.

To get intimate electrical connection of the conductors 40A, 40B into the carbon-containing material of layers 34A, 34B they are covered with the same liquid carbon polymer material 42A, 42B and cured. That may be done with further strips 44A, 44B of insulating tape previously applied over the side conductors 38A, 38B i.e. above their carrier strips 36A, 36B. If desired, for any reason such as aiding location of the looped extensions 40A, 40B, they may actually be laid on insulating strips first laid across the width of the tape 32 at appropriate intervals.

Afterwards, the whole of the tape is encased in insulating material, whether between further wider strips of insulation tape or by extrusion, see 46 in the drawing.

It will be appreciated that the aforesaid provision of comb-like conductors for feed and return may be done relative to the same surface coating of the tape, i.e. to a tape coated only to one side (34A or 34B), or separately for each major surface of the textile tape

32 in which case the textile core substrate tape 32 need not provide a uniform average mutual juncture of the coatings 34A, 34B, indeed any such juncture of the coatings 34A, 34B.

Finally, relative to the drawing, reference is made to end connectors 48A, 48B for the feed and return conductor 38A, 38B. Such end connectors may be made at each end of the tape 30 so that lengths thereof can, if desired, be connected in series.

Some advantageous features of heating tapes hereof have been mentioned above, and we now turn to further explanation of the advantages of having carbon as the electrically conductive element. Its uniform presence not only aids achievement of uniform, if required temperature-sensitive, electrical characteristics but also uniform thermal characteristics and the capability to absorb energy. Moreover, any tendency for creating static that arose previously using metal conductors is removed.

In an alternative construction as shown in Figures 3 and 4, a heating tape 50 having a similar core layer 52, i.e. impregnated with carbon-containing polymer material, has a different arrangement of its electrical conductors, see 58A, 58B. Thus, the conductor on one side, see 58A, crosses from side to side of the tape at suitably spaced intervals along its length in order to provide excursions, see 60A, across the width of the tape 50. The conductor 58A thus runs alternately along opposite edges of the tape for distances corresponding to said intervals. At such edge-adjacent runs, the conductor is electrically insulated from the core layer 52, whether by tape as aforesaid or by suitable L-or channel-section conductor carriers of insulation material, or both. The conductor 58B (see dashed fragments) is indicated on the other side of the tape in staggered relation to the conductor 58A. Suitable insulation material for the conductor carriers can be extruded plastics or rubber material, for example silicone rubber or aromatic polyamide textile. Only alternate lengths of such conductor carriers are specially shown as 56A, 56A' at opposite edges of the tape 50, but it will be understood that same can each be of the full length of the tape 50 with suitable notching of inner sides of channel-section carriers or with the upstand of L-section carriers outermost, otherwise using tape or equivalent to prevent through-conduction between the conductors 58A, 58B at corners to their excursions 60A, 60B.

The use of such zig-zag or meandering patterns for conductors 58A, 58B can afford advantages in fabrication techniques.

The use of extruded carriers 56A etc. can assist in avoiding any appearance of bumps over the conductors 58A, 58B in the finished product, i.e. if corner side or sides upstand by the thickness of the conductor, for which braided tinsel is preferred. Thus, final covering of the finished tape can then be via plastics extrusion then overlying the conductor carriers, conveniently using the same plastics material.

As before, the excurisons 60A, 60B are secured in intimate electrical connection with the carbon-containing polymer of the core layer 52 by application thereover of the same carbon-containing polymer, i.e. before the final extruded cover is applied.

It is found that braided tinsel conductors can afford satisfactory electrical conduction over up to 100 metres of the tape 50, and that excursion spacings of 2 metres for each of the conductors 58A, 58B with a 1 metre offset or stagger; i.e. setting up consecutive 1 metre long resistance regions of the tape 50, are satisfactory for achieving 11 to 12 watts per metre energy release as heat from A.C. mains electric supplies. Then, the effective resistances of such 1 metre by 25 centimetre regions should be about 1200 ohms for a 125-volt supply and about 4500 ohms for a 240-volt supply.

Any lengths and widths of the base fabric itself of any suitable type can, of course, be used.

Turning to Figures 5 and 6, instead of strip like excursions of side conductors as shown in Figures 2 to 4, transverse grooves 70 can be formed in tape 72 (similar to the tapes 10 and 50) in to which a mixture 74 of metal powder and polymer can be fixed with clip like connections 75 between the mixture 74 and the side conductors 76.

CLAIMS

1. A conductive material comprising carbon/graphite particles dispersed within and held together by a body of aliphatic and/or aromatic polymer.
2. A material as claimed in claim 1, wherein the polymer is a water based polymer.
3. A material as claimed in claim 1 or 2, wherein the polymer is polyacrylonitrile.
4. A material as claimed in claim 1 or 2, wherein the polymer is a polyurethane.
5. A material as claimed in any one of claims 1 to 4, wherein the carbon/graphite particles are present in an amount of from 12 to 55% of solid polymer by weight.
6. A material as claimed in any one of claims 1 to 5, further comprising a flame retarding additive.
7. A material as claimed in claim 6, wherein the flame retarding additive is present in an amount of from 20 to 40% of solid polymer by weight.
8. A material as claimed in claim 6 or 7, wherein the flame retarding additive is decabromodiphenyl oxide or antimony trioxide.
9. A conductive fabric comprising a fabric coated on one or both sides with a conductive material as claimed in any one of claims 1 to 8.

10. A fabric as claimed in claim 9 which is non-flammable.

11. A fabric as claimed in claim 9 or 10 based on polyamide.

12. A heating tape made from fabric as claimed in claim 9, 10 or 11.

13. A heating tape as claimed in claim 12 having energising conductors at sides of the tape.

14. A heating tape as claimed in claim 13, wherein areas of the conductive material are used to develop required electrical resistance.

15. A heating tape as claimed in claim 14, wherein the conductors are selectively insulated from the conductive material at either or both faces of the tape and effective selective interconnection of feed and return conductors relative to such areas are provided.

16. A heating tape as claimed in claim 15, wherein edge adjacent runs of conductors are electrically insulated from the conductive material and excursions of such conductors across the tape are made to define said areas.

17. A heating tape as claimed in claim 16, wherein said excursions are actually metal powder dispersed in polymer and held in grooves of the tape.

18. A heating tape as claimed in claim 17, wherein the metal powder is copper powder.

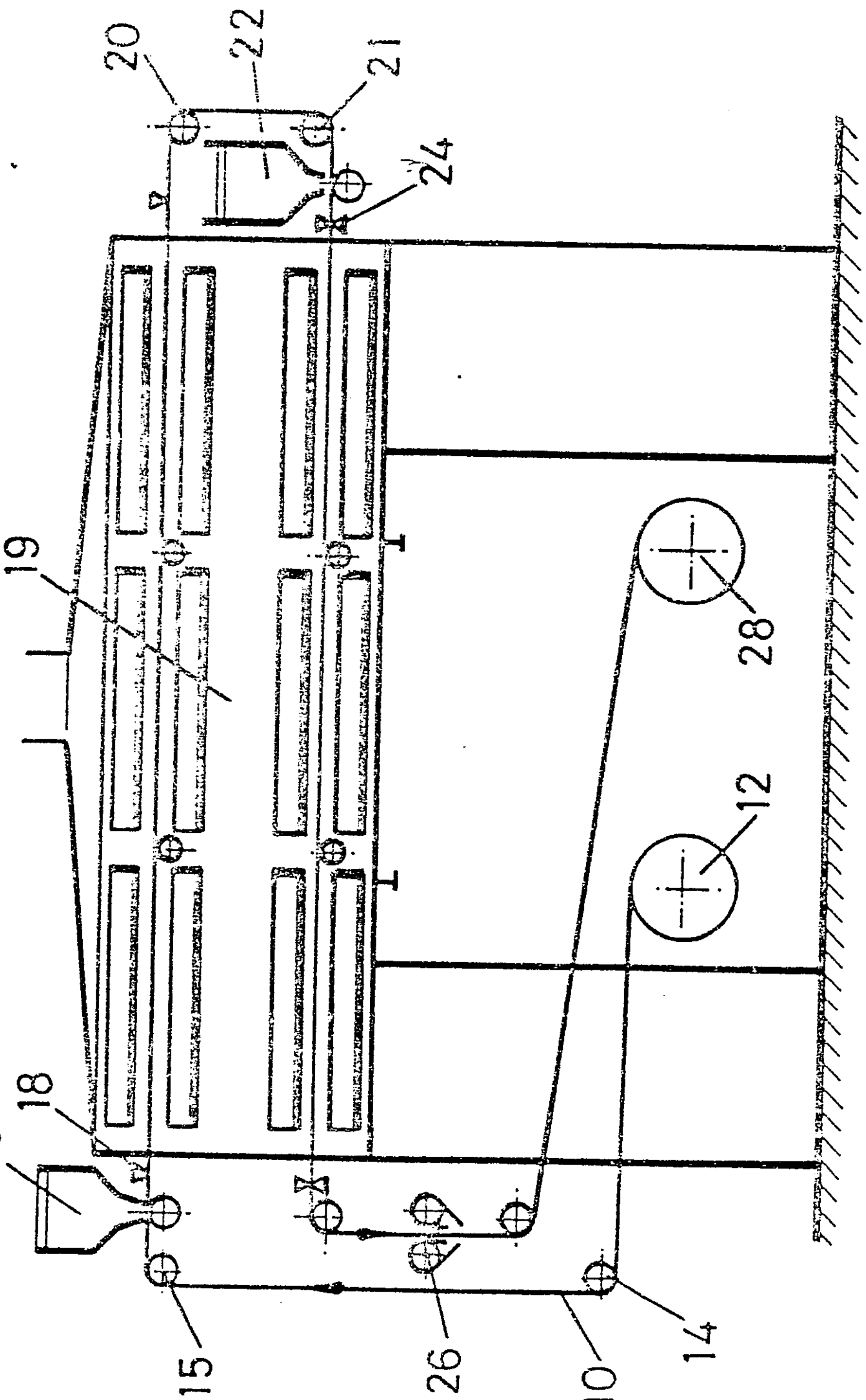

FIG. 1

0197745

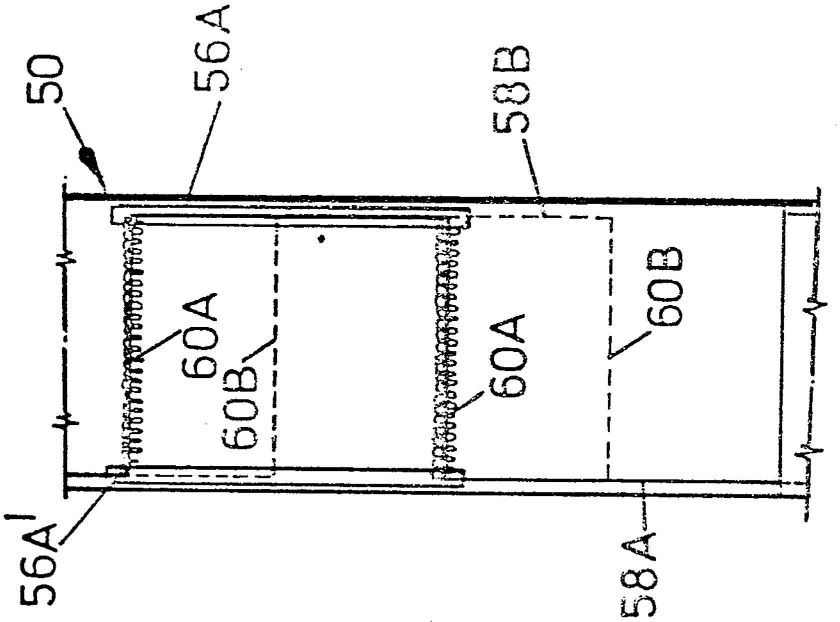

FIG. 3

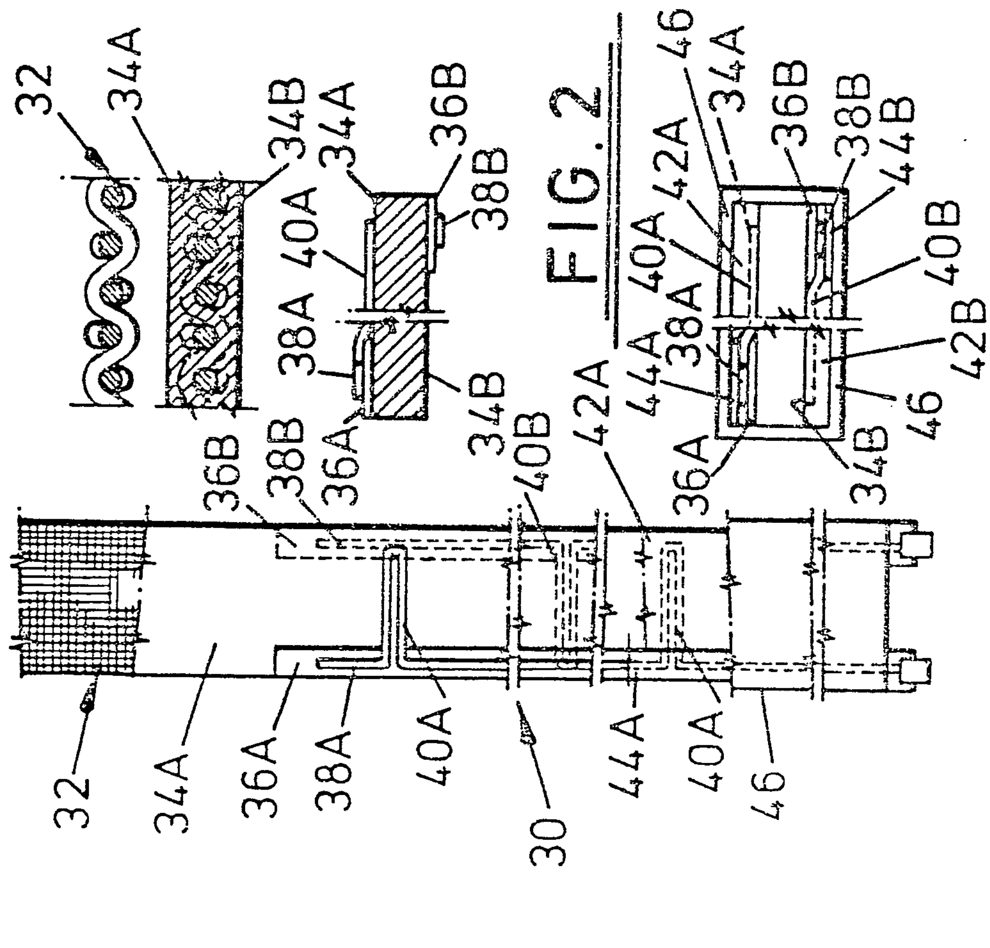

FIG. 2

0197745

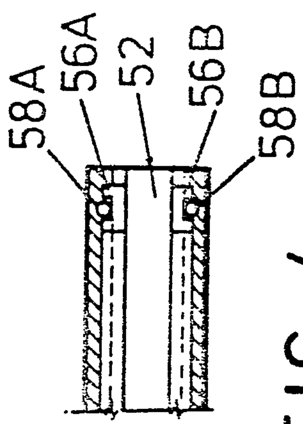

FIG. 4

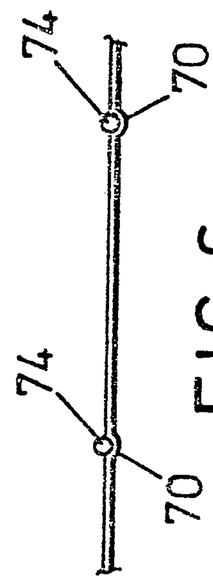

FIG. 6

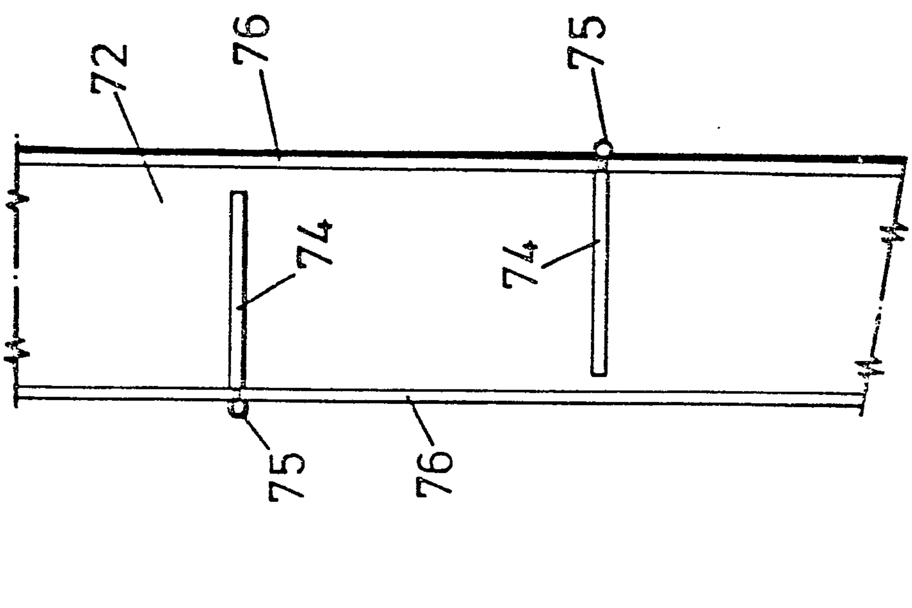

FIG. 5

0197745

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 86 30 2386

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl 4)
X,P	US-A-4 534 886 (R.G. KRAUS & AL.) * Whole document *	1-16	H 01 B 1/24
X	EP-A-0 129 193 (BASF) * Page 3, lines 35-40; page 4, lines 1-5; page 8, line 18; page 9, lines 26-30; claims 1-10 *	1,2,4-6,12	
A	FR-A-1 595 245 (GLANZSTOFF) * Abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl 4)
			H 01 B 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-06-1986	DROUOT M.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO Form 1503 03.82