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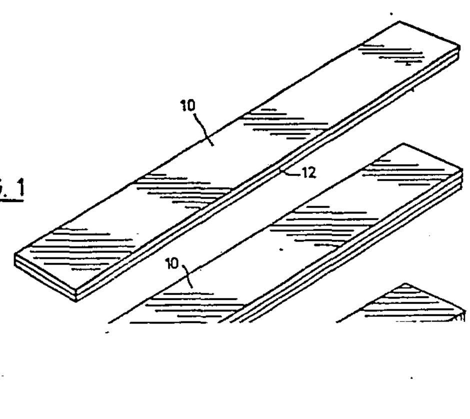
(54) **Electric fuses employing composite metal fuse elements.**

(57) High voltage current limiting fuse employing a composite metal fuse element, which consists of at least two portions of different metals (10, 12) with different electrothermal properties extending through the melt and arc zone, the two portions being bonded to one another along their adjoining faces for good thermal exchange. One metal of the composite should be of high conductivity and high melting point while the other is of low melting point, so that melting of the low melting point metal occurs at any and all locations along the element when its temperature reaches the said low melting point. The resulting composite exhibits properties that are not the mean of the metals employed and has a reversible resistance characteristic thus facilitating the design of the fuse for low current fault interruption. An element having a low melting temperature along its entire length results and giives essential arcing substantially simultaneously of the total element to improve the low current clearing performance of the fuse. The metals are selected from the group consisting of silver, copper, tin, nickel, lead, magnesium, zinc, aluminum and cadmium while the preferred combination is zinc and aluminum or cadmium and silver. A barrier may be provided between the two portions, such as a preformed alloy layer.

FIG. 1



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ELECTRIC FUSES EMPLOYING COMPOSITE METAL FUSE ELEMENTS

Field of the Invention

The present invention is concerned with imporovements in or relating to electric fuses employing composite metal fuse elements, and especially to such fuses of high voltage current limiting type.

Review of the Prior Art

It is known practice to protect an electric circuit by means of two different fuses, one of which is a current limiting fuse that will interrupt fault currents from its maximum interrupting rating to its minimum interrupting rating, and the other of which is a so-called weak link expulsion fuse that will interrupt fault currents a value from slightly above the minimum interrupting current rating of the current limiting fuse. Obviously it is desirable to eliminate the practice of using two fuses, but the design of fuses for interrupting low currents just above (e.g. two times or more) the maximum current rating of the fuse has been a constant problem to the fuse designers, and has added substantially to the complexity, size and cost of the fuses.

Fuse elements for such fuses commonly consist of one or more strips or ribbons of metal mounted in a suitable casing, and the design of such a fuse element requires the careful choice of different parameters among which are the metal from which the element is made, the dimensions of the strip or ribbon, whether or not the strip is notched or provided with eutectic spots (Metcalf effect) along its length; whether or not the element is wound on a ceramic or deionizing gas producing core; whether or not the element consists of two different metals connected in series; and the choice of the material surrounding the element. In a specific example, the ribbon may be of silver and provided along its length with up to about 100 notches, or holes, each of which is the potential site for melting and the initial formation of an arc; the element is completely buried in quartz sand which acts to absorb the energy generated by the arcs, and also to receive the melted element material.

The choice of the metal to be used is always difficult, since each metal usable in commercial practice has its own advantages and disadvantages. For example, silver has a desirable high conductivity and resistance to oxidation, but has a high melting point (960°C), and a high heat of evaporation and is costly. When spots of tin are soldered along the silver element to make use of the so-called Metcalf or M-effect a eutectic alloy is formed, the melting temperature being lower at the spot (approximately 230°C) to make the fuse applicable for low current operation, but such spots exhibit with time a non-reversible change under the effect of non-melting current flows that can lead to damage of the fuse. Additionally, while the spot initiates a single melt and subsequent arc at its location, approximately 700°C greater temperature is required to result in further melting of the silver sufficient to interrupt the high voltage circuit. The added time required for the small overcurrent to produce the much higher element temperature limits the effectiveness of the design.

Cadmium is a low melting point metal (321°C) with a very low temperature of evaporation (750°C). It has an excellent arc extinguishing characteristic and therefore it is widely used in electrical contacts. Moreover, it has very high burn-back rate and is very convenient for interruption of low currents. Cadmium has low conductivity and current carrying capacity while the resultant cadmium oxide is a very good insulator.

Zinc is a low melting point metal (419°C) that is resistant to oxidation, has a high burnback rate and has a non-linear coefficient of resistivity, which is useful, but has a conductivity 3-4 times lower than that of silver. Other metals and alloys thereof show some disadvantages when all of the necessary characteristics are evaluated.

Aluminum has a high current capacity and low melting point (658°C) and the oxide produced is non-conductive, which are all desirable, but the oxide film prevents disbursement of the melted metal into the surrounding sand and the melting characteristic for low currents applied for long times becomes inconsistent.

It is therefore an object of the present invention to provide a new electric fuse employing a new composite material as the fuse element.

In accordance with the present invention there is provided an electric fuse for use in circuits of at least 1000 volts comprising:

a tubular housing of insulating material;

two spaced terminals mounted on said housing for connection of the fuse in an electric circuit;

at least one metal fuse element mounted within the housing with the two ends of each element connected respectively to the said two terminals to form a respective conducting path therebetween;

each fuse element being embedded in and surrounded by silica sand disposed within the housing;

characterized in that:

each fuse element comprises at least two separate portions, each of which portions provides a corresponding continuous current carrying path between the said terminals;

at least two of the said portions are of two different respective metals that will not alloy to an appreciable extent under normal working conditions encountered by the fuse, each metal being present in the fuse element in an amount not less than 3% by volume of the total;

the said portions being bonded to one another at adjoining contacting surfaces to constitute a composite metal element;

the said different metals being of different electro-thermal properties such that each portion which is of one of the said metals will melt before the portion or portions of the other metal to increase the current density through the unmelted portion or portions.

The said one of said two metals may be of lower melting point.

The said one metal may be a low melting point metal selected from the group consisting of tin, lead, zinc and cadmium, and the said other metal may be a high melting point metal selected from the group consisting of silver, copper, nickel, magnesium and aluminum. There may be provided a barrier layer between the said adjoining contacting surfaces to inhibit alloying of the metals with one another.

Description of the Drawings

Particular preferred embodiments of the invention will now be described by way of example, with reference to the accompanying diagrammatic drawings, wherein:

Figures 1 to 4 are respective perspective views of preforms from which fuse elements of the invention can be formed.

Figure 5 is a perspective view of one form of fuse constructed according to this invention,

Figure 6 is a longitudinal cross-sectional view of the structure of Figure 5, parts thereof being shown broken away as necessary for clarity of illustration, and

Figure 7 is an enlarged view depicting the specific details of construction of the fuse elements shown in Figure 6.

Description of the Preferred Embodiments

A fuse element for use in an electric fuse of the invention consists of at least two separate metals, each of which is present in the form of at least one so-called separate fuse element portion, and preferably the different fuse element portions are metallurgically bonded to one another at their adjoining surfaces where they contact one another to form in effect a composite metal body.

For example, referring especially to Figure 1, the fuse element preform illustrated therein consists of two thin flat portions 10 and 12, each of which has the form of a thin flat strip or ribbon having two parallel wider faces and two parallel narrower faces or edges. The two strips are placed face to face and metallurgically bonded to one another by, for example, co-extrusion, cold rolling or by hot rolling at below the melting temperature of the lower melting material. In another method the portion of lower melting temperature metal is formed by casting against the body portion of the higher melting temperature metal, the resulting composite body then being extruded, cold or hot rolled, etc.

In another embodiment illustrated by Figure 2, more than two separate portions are employed (three in this example); the metal of the portions 10 and 14 can be the same, in which case the portion 12 is sandwiched between two identical other portions or they can be of different metals. In the embodiment illustrate by Figure 3 one portion consists of a plurality of uniformly-spaced metal wires or rods 10 which are enclosed in the second body portion 12 by casting the latter metal around them. The resultant rod or wire can then be rolled or extruded as required.

In the embodiment illustrated in Figure 4 a single body portion 10 is enclosed by the other metal portion 12. The metallurgical bonding of the two body portions at their abutting surfaces is further increased by hot rolling the cast body.

Each of the preforms illustrated is processed, for example, to give it the specific dimensions necessary for fuse elements; notching and mounting the element between a pair of fuse terminals; and embedding the element in a suitable surrounding medium, such as quartz sand, in a suitable container.

Referring now to Figures 5 to 7, there is illustrated therein an electric fuse consisting of a tubular housing 16 of an insulating material, provided with end caps 18 and 20 of a suitable conducting material at each end thereof. Outer caps 22 and 24 are secured about the end caps 18 and 20 respectively by a press fit and are secured to the tubular housing 16 by cement layers 26 and 28 respectively. An end terminal sleeve 30 and an end terminal cap 32 are fastened respectively to the inner surfaces of end caps 18 and 20, and the housing is filled with a granular filler consisting of silica sand 34. Disposed within the housing of the fuse and embedded within and supported by the sand filler are a plurality (5 in this embodiment) of coaxial helical fusible elements 36 through 44, each of which has its two ends connected respectively to the terminal 30 and 32. As is apparent from Figure 3 the helical fusible elements are each provided along its length with a large number of spaced notches 46.

The metals to be employed in a fuse element of the invention preferably are selected from the group consisting of silver, copper, tin, lead, nickel, magnesium, zinc, aluminum and cadmium. Of this group a preferred embodiment employs only zinc and aluminum either in the form of a sandwich (Fig. 2) or of a wire of aluminum, which has the higher melting point of the two, enclosed by the zinc which is cast around it, while another preferred embodiment employs only cadmium and silver either in the form of a sandwich (Fig.2), or of a wire of silver enclosed by the lower melting point cadmium which is rolled around it (Fig. 4).

It is found that in meeting the special requirements of a fuse element, the properties of this composite metal element are not simply the mean values for those of the two constituents, but are complex and differ in important respects therefrom. The temperature/time characteristics of the composites of the invention are characterized by two different stages. The initial stage is a normal exponential increase of temperature with time as the fuse is subjected to its normal load current. When an overload is present the temperature of course increases, and upon reaching the melting temperature of the lower melting component, there will be a rapid increase of temperature with time, due to a reduction in the cross sectional area of the element caused by successive melting of the lower temperature component and consequent increase in the current density through the remaining component. This marked increase in characteristic at a specific point permits a more accurate predetermination of the fuse melting characteristic, without this characteristic being unduly affected by aging or pre-melting temperature changes of the fuse element, resulting for example, from current surges passing through it. The temperature/time characteristic of the composite is therefore always reversible up to the temperature at which melting of the lower melting component begins, whereas by comparison the characteristic of a silver element with a tin eutectic spot was found to be irreversible thus leading to eventual damage.

The metals employed in a composite fuse element of the invention are specified as being different as to their electrothermal properties, by which are meant any one or more of their characteristics; resistivity, thermal conductivity, melting point, boiling point, heat of fusion, and heat of evaporation. It will be understood that different metals may have such similar electrothermal properties as not to be suitable for application of the invention. The different portions of the element have as intimate an interface as possible, in order to obtain the best possible electrical and thermal conductivity between the metals without having the undesirable interaction of two metals during the premelting time.

Each metal present in the composite should be present in an amount not less than 3% by volume of the entire element body, since otherwise there will not be sufficient present to significantly affect the properties of the composite. It will be apparent that each metal must be present in the form of a separate body or plurality of bodies that will extend through the intended melt and arc zone of the fuse element in the direction of flow of the current therethrough.

When two metals are employed in the composite one of them will be of high conductivity and high melting point (e.g. silver and aluminum in the preferred combinations), while the other is of low melting point(e.g. cadmium and zinc respectively), so that element melting is initiated at any and all locations along the element which reach the melting temperature of the low melting point constituent, starting, of course, at the notches 46. It will be seen that the preferred metals may be arranged in a high melting point group consisting of silve (960°C), copper (1083°C), nickel (1350°C), magnesium (651°C) and aluminum (658°C), and a low melting point group consisting of tin (232°C), lead (327°C), zinc (419°C), and cadmium (321°C), although the grouping in this manner does not preclude that a fuse element of the invention may be made using two metals from the same group.

The selection of the metals is based not only on their melting temperature, but also on the need to avoid any structural changes prior to the melting of the low melting component of the composite. Preferably the vaporisation temperature of the lower melting point metal is below the melting temperature of the other metal, since it will then be completely vaporised before melting of the other metal begins. Another preferred property of any combination is that the metals exhibit a peritectic effect.

However, bearing in mind that a fuse is expected to have a life of many years at its normal working temperature. there is the possibility of gradual alloying with time, resulting in a consequent change in characteristic . This effect may be inhibited by providing a suitable barrier layer between the adjoining contacting surfaces, the barrier layer being as thin as possible to provide the desired thermal exchange between the fuse element portions. Such a layer can consist for example, of a thin film of a preformed alloy of the two materials, which may additionally be pre-aged so that there are no substantial changes in characteristic with time. Other forms of barrier are a third metal, an oxide coating of one of the metals and an adhesive, preferably an organic adhesive so as not to react with the metals.

In the preferred cadmium/silver composite, the cadmium preferably is present in the amount of from 97 to 53% by volume with the balance silver. In a particular composite preform employed in the production of a fuse element for a 100 amp, slow-acting, general purpose, current-limiting fuse, in which the fuse element is of helical form embedded in quartz sand, the percentages by volume of cadmium to silver were 80 to 90 percent of cadmium with the balance silver. The melting characteristic of the resulting fuse element corresponds to that of cadmium with a melting temperature of about 320°C., the characteristic being fully reversible up to the melting point. The cadmium/silver combination also has the advantages that the vaporisation temperature of cadmium is below the melting point of silver, and in addition the metals exhibit a peritectic reaction with one another. Moreover, the cadmium oxide that results from the initial melting is a good insulator and therefore does not affect the fuse characteristic and establishes good dielectric strengths so as to assist the arc extinguishing process.

For the preferred zinc/aluminum composite the zinc preferably is present in the amount of from 97 to 53% by volume with the balance aluminum. In a particular composite preform employed in the production of a fuse element for a 100 amp, slow-acting, general-purpose, current-limiting fuse, in which the fuse element is of helical form embedded in quartz sand, the percentages by volume of zinc to aluminum were 80 to 90. The melting characteristic of the resulting element corresponds to that of an eutectic zinc/aluminum alloy with a melting temperature of about 380°C. It was found that the composite showed a non-linear increase in resistance with temperatures beginning at about 200°C, up to the melting point of 380°C, and that this increased resistance characteristic was fully reversibl up to the melting point.

It will be understood that other temperatures within the normal desired range of 200 to 400°C could be achieved by selection of other metals and/or proportions of the metals employed.

It is found that a fuse element of the form illustrated by Figure 2 is preferred, in which a high melting temperature strip is sandwiched between two low melting temperature strips. It is also found that there is a preferred ratio of width to thickness of each strip, and with the cadmium/silver combination this should be about 10:1, and may of course vary between say 8:1 and 12:1. An 80 amp fuse as described above will typically employ 12 helical elements connected in parallel each measuring about 2.5mm by 0.25mm.

The silica sand filler 34 preferably is in the form of approximately spherical grains of random size within a given range. These grains preferably are composed of at least 99% silica and approximately 98% of the grains are retained on sieve mesh size 100 while approximately 2% of the grains are retained on sieve mesh size 30. Approximately 30% of the grains are retained on sieve mesh size 40 while approximately 75% are retained on sieve mesh size 50. The pellets are identified as 109 G.S.S.

In the event of the occurrence of a high magnitude fault current such as many times rated load current, the fusible elements 36-44 melt practically simultaneously at all of their reduced sections 46 to form a chain of arcs. These arcs quickly lengthen and burn back from their roots. The energy of the arc in the form of heat is absorbed by the filler material in the granular form 34. The exchange of energy between the arcs and the filler material is influenced by the surface area of filler grains which is exposed to the arcs. The greater the area of this exposure the more efficient is the exchange of energy. This factor is facilitated by the use of the filler described and by the fact that the fusible elements are of ribbon form and that they are arranged as multiple elements rather than as one single element, although the invention in its broader aspects is not limited to a fuse using a plurality of parallel connected fuse elements.

Since the invention is concerned with high voltage currents of 1,000 volts and above, it is herein categorized as a high voltage fuse.

A fuse constructed according to this invention is well suited for use in protecting circuits and their connected apparat such as transformers, capacitors, switchgear and the like. By the invention a fuse is provided which is capable of effective fast acting current limiting action for currents of high magnitud and which also operates reliably for low currents which are but slightly in excess of the normal rated current of the fuse due in part to the fact that the fusible elements may be raised by relatively low fault currents to temperature levels approaching melting without establishing an excessively high overall fuse temperature.

It will also be noted that the preferred illustrated fuse is of coreless design which is to be preferred. In addition to their expense, cores are objectionable because contact with the fusible element reduces the area over which energy exchange between the arcs and the filler material can take place. Since the interrupting process requires that most of the arc energy be transferred to latent heat of fusion of the filler material any reduction of the area of contact with the filler material is undesirable. Moreover, the areas of contact between the elements and core can produce high temperatures in the core. The ceramic materials commonly used exhibit marked reduction in their insulating properties at such elevated temperatures. This reduction in insulating property of the core results in a non-uniform voltage distribution across the fuse in the period following arcing.

Under certain transient current conditions, an appreciable temperature rise in the fusible elements may occur and may cause a deformation of the fusible elements. Repeated heating and cooling cycles may impose increasing tensile load on the fusible elements since they may not straighten out due to construction of the sand. If movement of the elements is possible, as in a coreless construction, this tension may be relieved. In elements wound on a core, the opportunity for relieving tension is severely restricted and mechanical failure due to this increased tension may occur, since the increases may be sufficient to break the fusible element, particularly at the reduced cross section notches.

1. A current limiting electric fuse for use in circuit least 1000 volts comprising:

a tubular housing of insulating material;

two spaced terminals mounted on said housing for connection of the fuse in an electric circuit;

at least one metal fuse element mounted within the housing with the two ends of each element connected respective the said two terminals to form a respective conducting path therebetween;

each fuse element being embedded in and surrounded b silica sand disposed within the housing;

characterized in that:

each fuse element comprises at least two separate portions, each of which portions provides a corresponding continuous current carrying path between the said terminals;

at least two of the said portions are of two differe respected metals that are metallurically isolated from one another, each metal being present in the fuse element in an amount not less than 3% by volume of the total;

the said portions being bonded to one another at adjoining contacting surfaces to constitute a composite metal element;

the said different metals being of different electro thermal properties such that each portion which is of one of t said metals will melt before the portion or portions of the ot metal to increase the current density through the unmelted por or portions.

2. An electric fuse as claimed in claim 1, characterized in that the said two metals react peritectically.

3. An electric fuse as claimed in claim 1 or 2, characterized in that the metals from the said portions are selected from the group consisting of silver, copper, tin, lead, nickel, magnesium, zinc, aluminum and cadmium.

4. An electric fuse as claimed in claim 1 or 2, characterized in that the said one metal is a low melting point metal selected from the group consisting of tin, lead, zinc and casmium, and the said other metal is a high melting point metal selected from the group consisting of silver, copper, nickel, magnesium and aluminum.

5. An electric fuse as claimed in claim 4, characterized in that the selected metals are cadmium and silver.

6. An electric fuse as claimed in claim 5, characterized in that the fuse element comprises from 90 to 50% by volume of cadmium with the balance silver.

7. An electric fuse as claimed in claim 4, characterized in that the selected metals are zinc and aluminum.

3. An electric fuse as claimed in claim 5, characterized in that the fuse element comprises from 90 to 50% by volume of zinc, with the balance aluminum.

9. An electric fuse as claimed in any one of claims 1 to 8, characterized in that there is provided a barrier layer between the said adjoining contacting surfaces to inhibit alloying of the metals with one another.

10. An electric fuse as claimed in claim 9, characterized in that the said barrier layer consists of an alloy of the two metals.

11. An electric fuse as claimed in claim 10, characterized in that the said barrier layer consists of an aged alloy of the two metals.

12. An electric fuse as claimed in claim 9, characterized in that the said barrier layer consists of a third metal.

13. An electric fuse as claimed in claim 9, characterized in that the said barrier layer consists of an organic adhesive.

14. An electric fuse as claimed in claim 9, characterized in that the said barrier layer consists of an oxide coating of one of the metals.

15. An electric fuse as claimed in any one of claims 1 to 14, characterized in that each fuse element portion is in the form of a single thin flat strip having two wider faces and two narrower faces, and each strip has at least one wider face adjoining and contacting a wider face of the immediately adjacent strip.

16. An electric fuse as claimed in any one of claims 1 to 14, characterized in that each fuse element portion is in the form of a plurality of thin flat strips, each strip having two wider faces and two narrower faces, and each strip has at least one wider face adjoining and contacting a wider face of the immediately adjacent strip, which is of a different metal.

17. An electric fuse as claimed in claim 15 or 16, characterized in that the width to thickness ratio of each strip is in the range 8:1 to 12:1.

18. An electric fuse as claimed in any one of claims 1 to 14. characterized in that one fuse element portion of higher melting point metal is in the form of a wire or rod or sandwich, a second fuse element portion of lower melting point metal surrounds the said wire or rod and encloses it.

19. An elcetric fuse as claimed in any of claims 1 to 18, characterized in that each fuse element is provided along its length with a plurality of spaced notches to provide respective sites of increased current density and consequent increased temperature.

20. An electric fuse as claimed in any one of claims 1 to 19, characterized by a plurality of coaxial helical elements each connected respectively to the said two terminals.

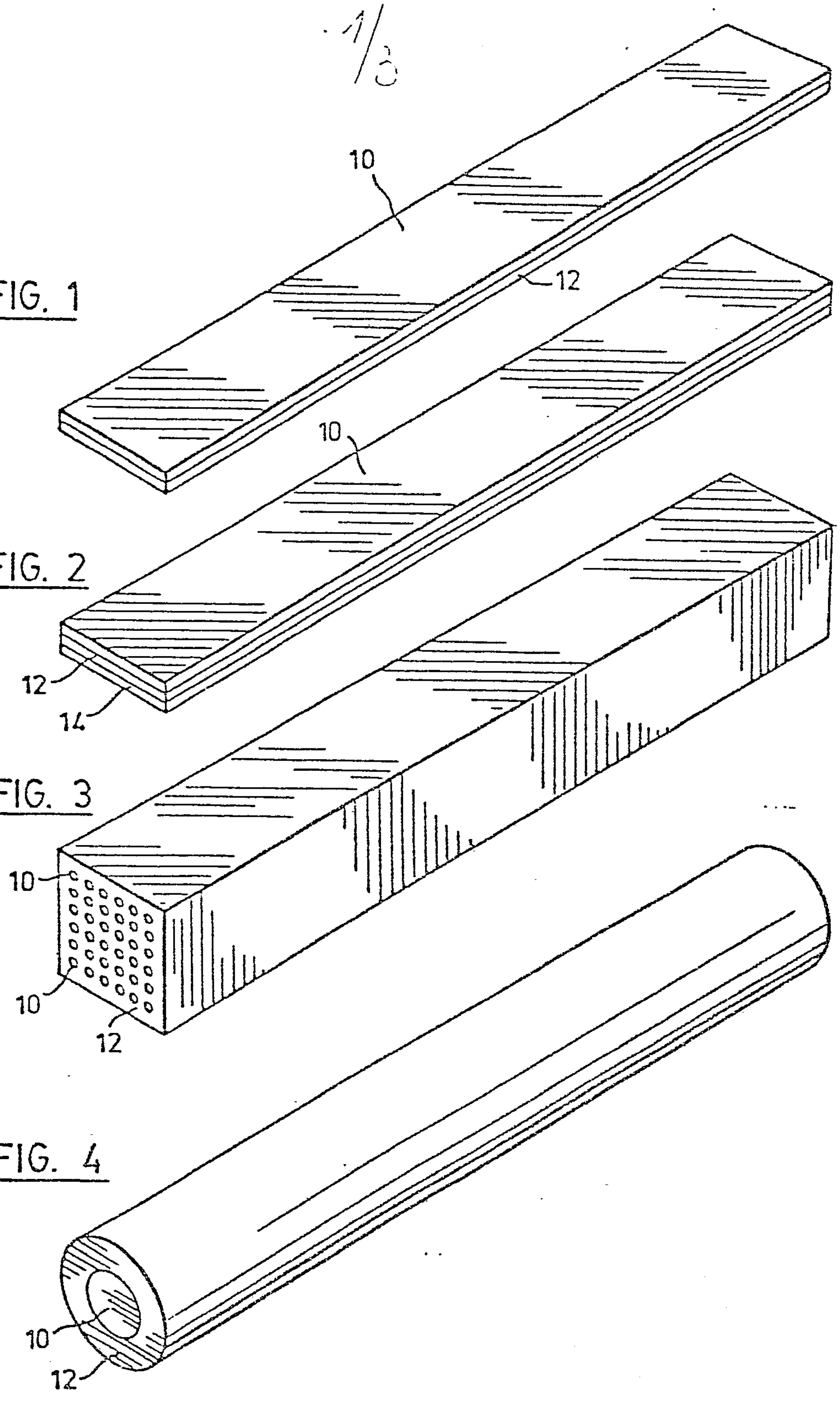

FIG. 1

FIG. 2

FIG. 3

FIG. 4

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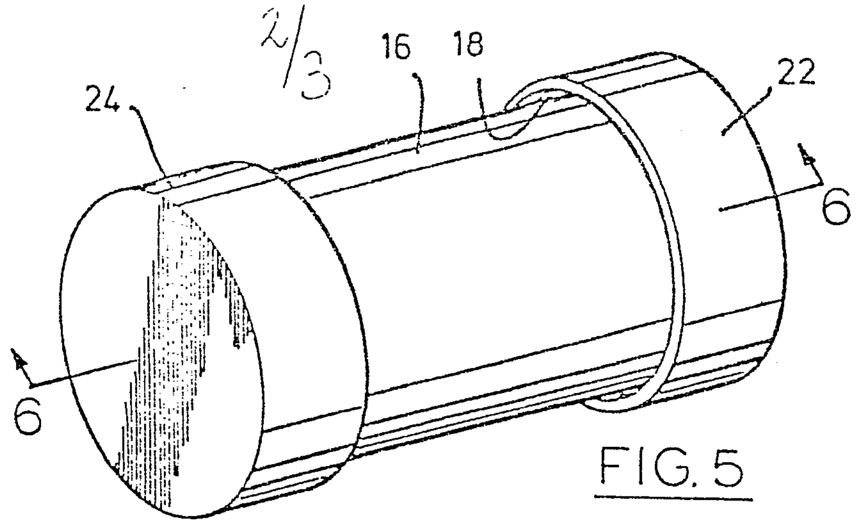


FIG. 5

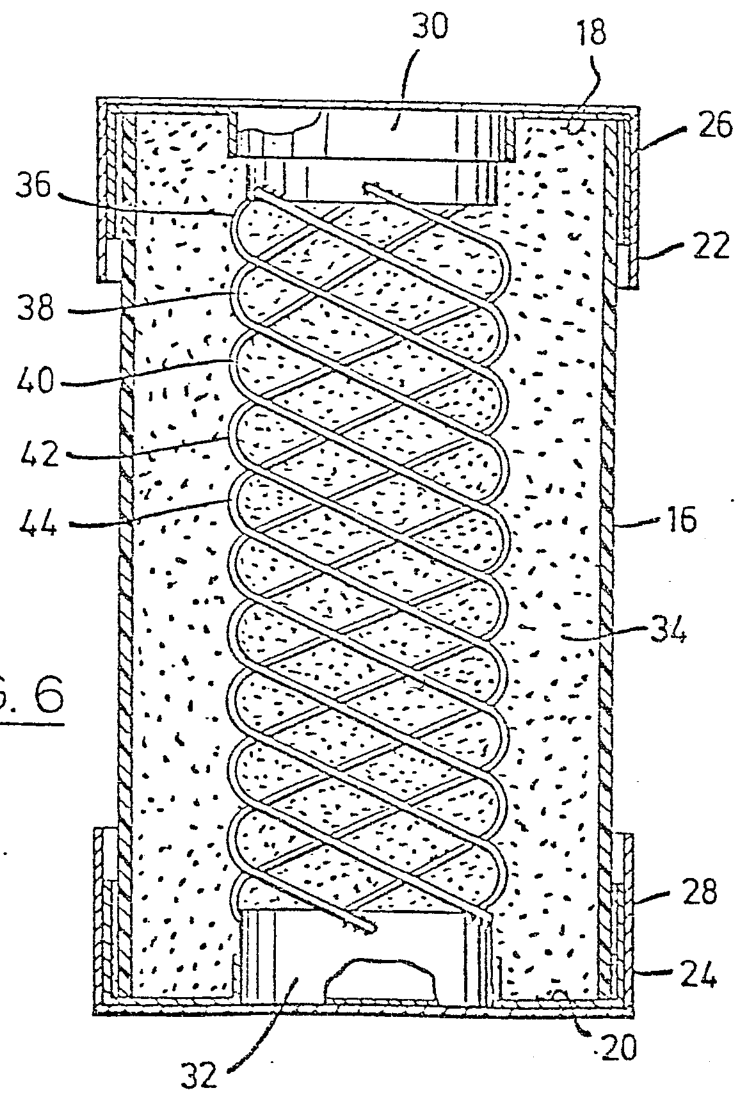
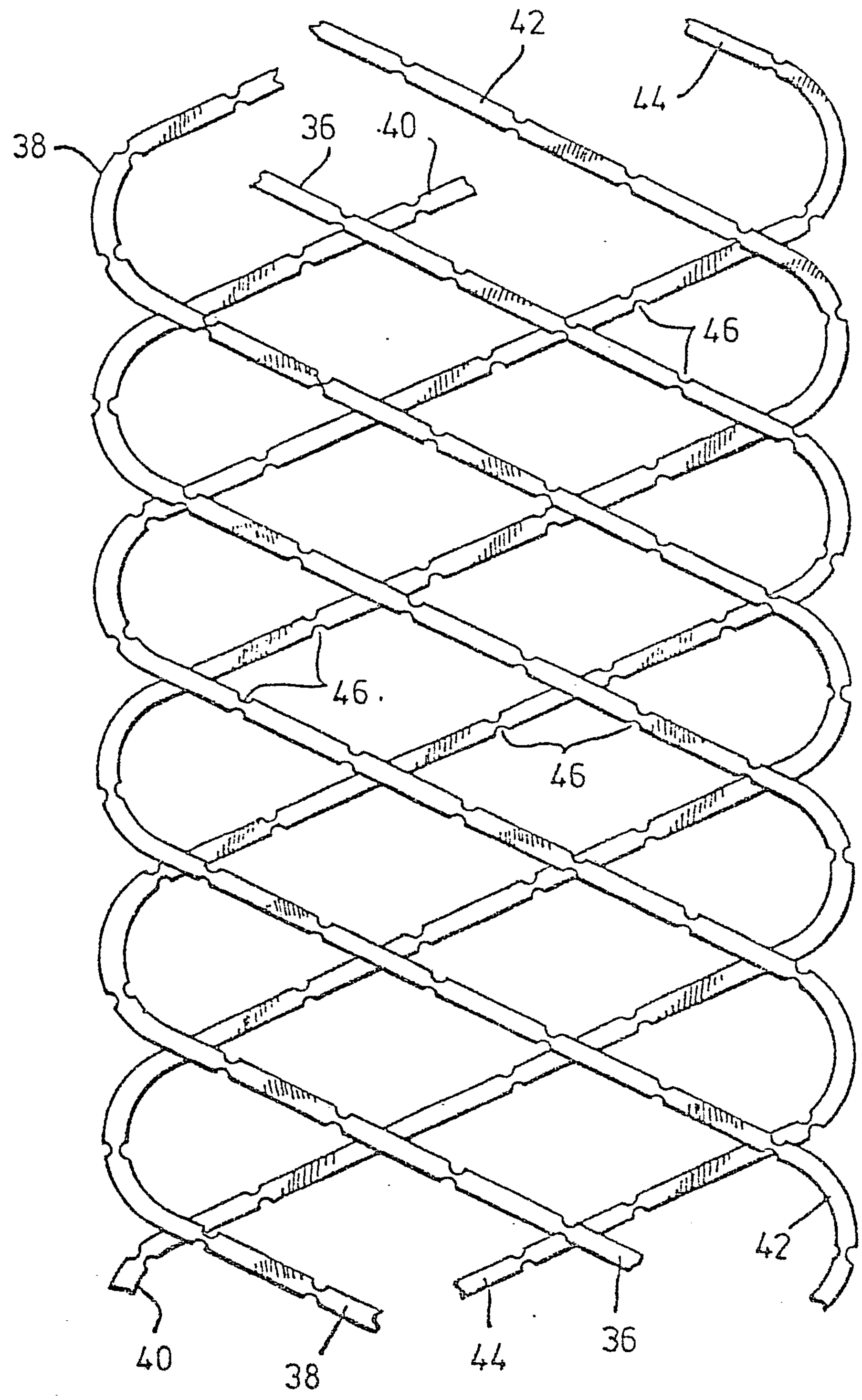


FIG. 6

FIG. 7



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EUROPEAN SEARCH REPORT

Application number
EP 80 10 1485

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	DE - C - 624 633 (SIEMENS) * Page 1; page 2, lines 1-82; 94-98 *	1,3,4, 9-11, 18
	--	
X	FR - A - 445 270 (HOPE) * Whole document *	1,3,4, 18
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X	US - A - 3 268 691 (McGRAW-EDISON) * Whole document *	1,18, 20
	--	
X	DE - A - 2 551 627 (BORCHART) * Whole document *	1,3,4, 9,12, 13,18
	--	
	US - A - 3 869 689 (MIKIZO KASAMATU) * Whole document *	1,3,4, 9,13, 18
	--	
	DE - C - 717 681 (WICKMAN-WERKE) * Whole document *	1,3,4
	--	
	DE - A - 1 563 785 (SIEMENS) * Pages 1-4; page 5, lines 1-9; 13-15 *	1,3,4, 15-17, 19
	--	
	DE - C - 664 793 (SCHIELE) * Page 2, lines 117-119; page 3, lines 36-39 *	1,3-5
	-- ./.	

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

H 01 H 85/04

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

H 01 H 85/04
85/06
85/08
85/10
85/12

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27-06-1980	DESMET

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EUROPEAN SEARCH REPORT

Application number
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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. 3)
	US - A - 3 810 062 (KOZACKA) * Column 6, lines 14-26,48,49, 54-57 * ----	1,19, 20	

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)