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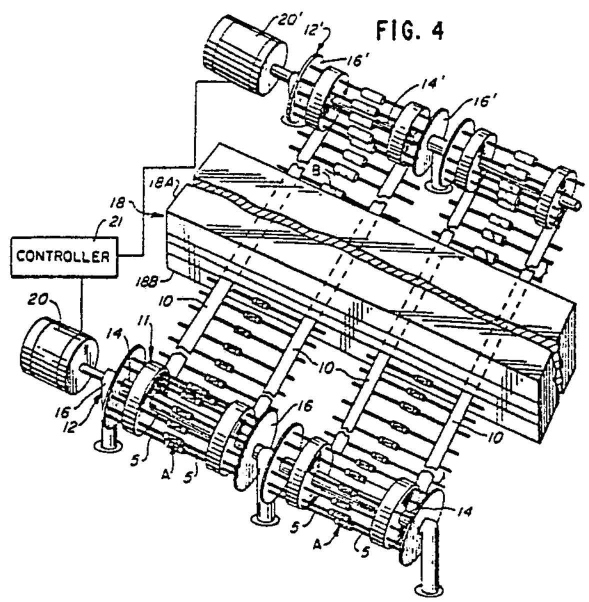
(54) **Method of making an encapsulated fuse and the fuse made thereby.**

(57) A method of making a cartridge-type fuse involves forming a subassembly comprising an inner insulating housing preferably made of a transparent glass material, end cap terminals at the ends of the housing and leads extending axially therefrom. A preferably transparent encapsulating body is molded around the inner housing which covers, seals and physically interconnects the exposed exterior surfaces of the inner housing, terminal means and a portion of each lead adjacent to the terminal means. The molding operation is preferably carried out by unwinding a roll of the fuse subassemblies having their leads secured between a pair of carrier strips wound up with the subassemblies into a roll and supported on a rotatable supply reel. The reel is unwound in intermittent steps to bring a predetermined number of the subassemblies between pairs of mold cavity-forming elements initially separated and then brought together around the fuse subassemblies to mold the encapsulating bodies therearound. The completed encapsulated fuses carried between the carrier strips are then would upon a take-up roll for storage or shipment to the ultimate user.

FIG. 4



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METHOD OF MAKING AN ENCAPSULATED FUSE AND THE FUSE MADE THEREBY

Technical Field

The present invention relates to improvement in electrical fuses, particularly to miniature cartridge fuses where, typically, the fuse blowing conditions have heretofore required ceramic fuse housings to prevent the fuse from blowing up under severe high overload conditions. More specifically, the invention is an improvement in the miniature fuse disclosed in U.S. Patent No. 4,460,887, granted July 17, 1984, and which, in its most useful form, can have an overall diameter of as little as about 0.1 and a housing length as short as about one quarter inch, even for rated current of as much as 15 amps. The invention has also been used on 100 amp fuses with a diameter of about .250 inches and a length of about 0.4 inches.

Background of Prior Art

Cartridge type electrical fuses having axial lead have been long known in the fuse art. The fuse element in such a fuse is typically a fusible wire supported within a cylindrical open-ended insulating housing for the fuse and closed by metal end caps carrying outwardly axially extending leads. To insure reliable fusing it is essential that the fuse wire must not touch the interior wall of the housing along the portion of its length which can affect its fuse blowing characteristics; hence, the ends of the fuse wire are supported in such a manner as to prevent such contact. Ins some fuse designs, the fuse element extends diagonally across the sleeve ends. In such case, the lead carrying end caps having solder therein are used to capture the fuse wire ends folded over the outside of the sleeve ends. The final mechanical assembly consists of press fitting the end caps over the folded-over ends of the fuse wire followed by momentary heating of the solder to obtain good electrical connection between the fuse wire and the end caps.

Where the fuse was a miniature fuse having a housing typically made of ceramics material which cannot be solder bonded without adding a metal coating, the only substantial opposition to the separation of the end caps from the sleeve was derived from the pressure fitting of the end caps overs the outer surface of the housing. Thus, such fuse structures were generally weak in tension, and were prone to mechanical failure on a pull test applied to the end leads. An alternative construction was to solder bond the end caps to the housing ends, which requires an expensive local outer metallization of the housing ends. Such structures are prone to humidity induced corrosion problems because of the exposed metal end caps and the lack of any hermetic sealing thereof.

One prior art partial solution to the above-mentioned problems was the application of a length of heat-shrinkable plastic tubing tightly heat shrunk over the housing and end caps, the tubing overlapping, although loosely, the inner ends of the leads extending outwardly from the end caps. The heat shrunk tubing provided some improvement in fuse strength and provided a moderately good sealing for the fuse interior. A disadvantage of this construction was that the cap ends are exposed to the external ambient conditions, owing to the fact that the limited shrinkage capability of the tubing prevented a desired end cap sealing engagement of the heat shrunk tubing prevented a desired end cap sealing engagement of the heat shrunk tubing with the leads. Such sealing is desirable when the fuse is used on printed circuit boards which, after complete assembly of parts on the board, is often dropped into a liquid solvent to clean the board. Also to impart a desired adequate corrosion resistance to the end caps, it was still necessary to plate the still exposed end caps with a corrosion resistance material.

In the fuse encased by the shrink fitted tubing, the resulting structure was still not adequately strong, in that a moderate pull on the leads can still sometimes shift the end caps to break the fuse wire. The shrink tube fitted fuse as described also was more costly to manufacture than desired. Also, because the fuse housing was made of an opaque ceramic material, the fuse wire was not visible even when the shrink tubing was transparent.

To partially overcome the problems referred to, the invention disclosed in U.S. Patent No. 4,460,887 was developed. As disclosed therein, instead of using shrink tubing as described, an encapsulating body of insulating material, such as an opaque epoxy material, was applied to the fuse so as to cover, seal and physically interconnect the exposed exterior surfaces of the housing, the end cap and each of the leads extending from the end caps.

As explained in this patent, the epoxy insulating coating was formed by initially applying epoxy powder to a rotated fuse which had been preheated to fuse the epoxy powder. Because of the temperatures involved, it was discovered that blow holes developed in the epoxy encapsulating body because of out-gassing caused by the heating of the fuse to the epoxy powder fusing temperature. When these fuses were subject to severe high current overload circuit tests, it was found that the blow holes undesirably reduced the insulation resistance of the encapsulating body. Also, the epoxy material was a translucent material so that the fuse wire was not visible, even if the housing were to be made of a transparent material.

It is one of the objects of the present invention to provide a new method of making a sealed miniature fuse which is less costly and more effective than that just described. Another object of the invention is to provide a method of making a sealed miniature fuse where the fuse is a unique, more reliable one than that produced by the method just described, and, most desirably, where the fuse wire is visible from the outside of the fuse so that a blown fuse condition can be visibly determined.

Brief Summary of Invention

In accordance with one of the aspects of the invention, the encapsulating body used to seal the fuse to impart an increased terminal pull strength is made of material and is formed in a manner where it also serves as the main support structure for the entire fuse, making it possible to form the fuse housing of a relatively weak transparent glass housing. Thus, for example, it was discovered that by molding a strong synthetic plastic material like transparent polypropylene around a fuse subassembly having a relatively weak transparent housing so that it encapsulates the housing, the terminal end caps and a portion of the terminal leads, the molded encapsulating body acts as the main structural support for the entire fuse. Thus, the fuse withstands high terminal pulling forces and the high pressure-producing conditions caused by high overload fuse blowing conditions and no arcing occurs between the fuse terminals. Moreover, the encapsulating material can be a transparent material so that the condition of the fuse wire can be readily visibly determined.

Another aspect of the present invention is the unique method for making the fuse. While molding techniques have been heretofore used to form a fuse housing around a fuse wire, it is believed unique to mold a relatively strong encapsulation body around a pre-assembled fuse already having a relatively weak glass or glass-like housing to encapsulate an inner fuse housing, end terminals, and the innermost portions of the connecting leads extending from the end terminals.

Another aspect of the invention is the unique manner in which the molding operation is carried out. First of all, the leads of the fuse subassemblies are secured between a pair of adhesive carrier strips wound up with the subassemblies into a roll supported on a rotatable supply reel. The roll is unwound from the supply reel in a step-by-step fashion and delivered to a molding station which can mold an encapsulating body simultaneously around a large number of fuse subassemblies. These and other features of the invention will become apparent upon making reference to the specification and drawings.

Brief Description of Drawings

Figure 1 is an elevational view of a fuse made by the process of the invention;

Figure 2 is a partially longitudinal sectional view of the fuse shown in Figure 1 showing the outer encapsulation body molded around a main fuse subassembly;

Figure 3 is a complete longitudinal sectional view through the fuse of Figure 1;

Figure 4 is a perspective view illustrating the preferred method used to mold an encapsulating body around each fuse subassembly;

Figure 5 is a vertical transverse section view through the mold assembly showing two cavities and the upper and lower mold-forming parts of this assembly which are respectively moved between spaced and contiguous positions where a mold cavity is formed around one of the fuse subassemblies; and

Figure 6 is a transverse sectional view through Figure 5, taken along section plane 6-6.

Detailed Description of Invention

Referring to Figures 1-3 where the fuse 1 of the present invention is shown comprising a main fuse sub-assembly A encapsulated by a transparent encapsulating body B. The subassembly comprises a length of fuse wire 7 held captive at the ends of an initially open ended cylindrical inner glass housing 2 by means of a pair of cup-shaped metal terminal end caps 3-3 having cylindrical interior recesses receiving the ends of the housing 2 with a pressure fit. A body of solder 4 in each end cap 3 is heated to wet the fuse wire and secure it to the end caps 3-3. Shouldered connecting leads 5-5 pass through the center of the caps 3-3 and are secured by staking prior to assembly of the fuse structure.

The encapsulating body B provides improved structural strength and a complete sealing of the housing 2 and end caps 3-3. The resulting structure is substantially hermetically sealed and, thus, requires no plating of the end caps 3 for corrosion protection, thus resulting in a cost economy in manufacture. The encapsulating body covers the outer exposed surfaces of the housing 2, end caps 3-3, and portions of the lead 5-5 adjacent to the end caps to form a reinforced sealed body which greatly increases the insulation resistance and pull strength of the fuse.

The fuse rating 9 may be imprinted at one or both end portions of the encapsulating body B where the subassembly end caps 3-3 are located, to avoid interfering with th view of the fuse wire 1 visible through the transparent walls of the encapsulating body B and inner housing 2.

The encapsulating body B may be a polypropylene or other suitable moldable synthetic plastic material, such as Rynite or Nylon. It is preferred that a thermoplastic material be used which can be quickly injection molded with water cooled molding equipment of the kind to be described. The fuse subassembly is not preheated as in the epoxy encapsulating process disclosed in U.S. Patent NO. 4,460,887, and so no out-gassing occurs to form blow holes which decreased the insulation resistance of the fuse exterior of the sealed fuse disclosed in the previously mentioned patent. Also, because the epoxy powder application process disclosed in this patent required rotation of the fuse subassembly during application of epoxy powder, the encapsulation process could not be as easily and quickly carried out as in the encapsulation process now to be described.

Refer now to Figure 4-6 for a disclosure of the most preferred method for molding the encapsulating body B around each of the fuse subassemblies. As there shown, there are provided two adjacent lines of fuse subassemblies A which are fed through a mold assembly 18 which can simultaneously mold a large number of encapsulation bodies B, such as 25 per line. One of these lines will now be described, it being understood that the other line of fuse subassemblies have encapsulation bodies molded in the same way now to be described. Each line of fuse subassemblies A are supported preferably in a horizontal orientation and at longitudinally spaced points along a pair of horizontally spaced adhesive strips 10-10. The leads 5-5 are shown removably secured to the adhesive coated sides of the strips 10-10. The strips 10-10 are preferably horizontally oriented so that the adhesive coated sides are horizontal co-planar surfaces of the strips. These strips, together with the fuse subassemblies carried thereby, are wound up into a roll 11 upon a supply reel 12.

The supply reel assembly 12 includes a shaft 14 having fuse lead positioning flanges 16-16 between which the outer ends of the fuse assembly leads 5-5 are retained. The roll 11 of carrier strips are fuse subassemblies are unwound from the supply assembly reel 12 and moved to the mold assembly 18. When the carrier strips and fuse subassemblies leave the mold assembly 18, the encapsulation bodies B are molded around the fuse subassemblies A. The encapsulated fuse body assemblies and the carrier strips to which the leads thereof are attached are then moved to a take-up reel assembly 12′ having lead-confining flanges 16′-16″ similar to the flanges 16-16 on the supply reel assembly 12. The carrier strips 10-10 are rolled upon the shaft 14′ of the reel assembly 12.

The take-up reel shaft 14′ is connected to a suitable stepping motor 20′. A similar stepping motor 20 is connected to the supply reel assembly shaft 14. The motors 20 and 20′ are fed stepping pulses from a controller 21 intermittently to move the 25 fuse subassemblies A of each line on the associated carrier strips 10-10 to the mold assembly 18, as a like number of encapsulated fuse subassemblies are moved from the mold assembly 18 toward the take-up reel assembly 12′.

Refer now to Figures 5-7, where exemplary apparatus for molding an encapsulating body B around each fuse subassembly is shown. Figure 5 is a transverse cross sectional view through the mold assembly 18, showing two mold cavities 22-22, one for each line of fuses being processed. Each cavity 22 is formed by upper and lower semi-cylindrical recesses 22A and 22B (Figure 6) formed in the upper and lower faces of upper and lower mold assembly parts 18A and 18B. These parts are water cooled by the passage of water through passageways 20A-20B in the upper mold assembly part 18A.

When the upper and lower mold assembly parts 18A and 18B are brought together, they define the described mold cavities, each of the size of the encapsulating body B to be formed.

The referred to upper and lower mold assembly part 18A and 18B are each made up of an assembly of parts, all of which will not be individually described. These parts are carried on movable elements (not shown) which bodily move these parts vertically between spaced and contiguous positions. When the subassemblies are moved to the molding assembly 18, the mold assembly parts 18A and 18B are separated to avoid interference with the movement of these subassemblies. The subassemblies come to rest within the mold assembly, the mold assembly parts are then moved into confronting relationship where the mold cavities are formed therebetween and the molding material fed thereto. The molding material immediately hardens and the mold assembly parts are then separated to permit the molded subassemblies to move on to the take-up reel assembly to enable the subassemblies not yet encapsulated to be moved to the mold assembly.

Communicating with each upper recess 22A in the mold assembly part 18A is a nozzle 24 defining a molding material inlet passageway 24. The nozzle is formed by a metal body having an insulating sleeve 26 which retains heat generated in the interior thereof. The nozzle body illustrated has a pair of molding material feeding passageways 28-28 communicating with the inlet passageway 24. A heating element 30 in the center of the nozzle body generates heat within the nozzle body to keep the thermoplastic molding material involved in a plastic state within the inlet passageway 24. The passageways 28-28 in each nozzle body communicates with a main feed passageway 28′ in turn fed from one or more molding material inlet ports 31 provided at the tope of the mold assembly part 18A. The ports 31 communicate with a source of molding material which can be fed by a feed screw (not shown) which is intermittently rotated to feed a fixed predetermined amount of molding material from passageway 24 into the associated mold cavity 22 after the mold assembly parts 18A-18B are brought together.

The upper mold assembly part also has heating elements 30′ to keep the molten material in the passageway 28′ in a molten state at all times. To stabilize the temperature involved, a power and thermocouple mold plug 34 is provided which controls current flow from a suitable current source to the heating elements 30 and 30′ contained in the upper mold assembly part 18A. Because substantially the entire surface area of the mold cavity defined by the recesses 22A-22B are cooled surfaces, the encapsulating bodies B are quickly formed in a hardened state. When the mold assembly parts 18A and 18B are then separated, the hardened encapsulating body B is cleanly separated from the still molten material in each passageway 24. The entire surface area of the encapsulating body B is a smooth cylindrical surface when the molded cavity-forming parts are separated.

One example of a fuse made in accordance with the present invention having a 15 amp rating and a glass housing length of .228 inches, a housing outer diameter of .055 inches, a housing wall thickness of .013 inches, an end cap outer diameter of .073 inches, an encapsulating body outer diameter of .095 inches, a lead diameter of .024 inches, and a lead pull strength of well above 10 pounds.

The present invention thus provides a high speed, reliable and effective method for making the unique encapsulated fuses of the present invention.

While the invention has been described with reference to be a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the broader aspects of the invention. Also, it is intended that broad claims not specifying details of a particular embodiment disclosed herein as the best mode contemplated for carrying out the invention should not be limited to such details. Furthermore, while, generally, specific claimed details of the invention constitute important specific aspects of the invention in appropriate instances even the specific claims involved should be construed in light of the doctrine of equivalents.

Claims

1. A method of making a cartridge-type fuse comprising:

(a) forming a subassembly comprising an inner insulating housing made of a relatively weak glass or glass-like material, a fuse element disposed within said inner housing, a pair of conductive terminal means at the opposite ends of said housing electrically and physically connected to the ends of said fuse element, and a conductor lead externally connected to each terminal means and extending outwardly axially from the housing, for making external electrical connection to said fuse element through said terminal means; and

(b) molding around said inner housing, terminal means and a portion of said leads adjacent to said terminal means an outer encapsulating body of relatively transparant insulating material covering sealing and physically interconnecting the exposed exterior surfaces of said inner housing, terminal means and a portion of each lead adjacent to said terminal means.

2. The method of claim 1 wherein said inner housing and outer encapsulating body are both made of transparent material, so that said fuse element is visible from the exterior of the completed fuse.

3. The method of claim 1 or 2 wherein said inner housing is an open ended body, and said terminal means are cup-shaped end caps telescoping over the ends of said housing.

4. The method of claim 3 wherein said fuse element is a fuse filament extending diagonally across opposite ends of said inner housing and being sandwiched between the cup-shaped end caps and the outer surfaces of said inner housing.

5. The method of claim 1 wherein the leads of a plurality of said subassemblies are secured between a pair of carrier strips would up with the subassemblies into a roll supported on a rotatable

supply reel, said roll is unwound from said supply reel and fed to a molding station where said encapsulation body is molded around each subassembly.

6. The method of claim 5 wherein said molding station includes a plurality of pairs of mold cavity-forming members which are movable between spaced apart positions where the subassemblies and carrier strips can move therebetween, and closely confronting positions where mold cavities for forming said encapsulating bodies are formed therebetween, the roll of subassemblies and carrier strips being intermittently unwound a given amount to remove any fuse subassemblies with encapsulating bodies molded therearound from the molding station, and to bring a like number of subassemblies not yet encapsulated between said pairs of spaced mold cavity-forming members, said pairs of mold cavity-forming members then being brought together where the moldable encapsulating material involved is fed to the mold cavities.

7. The method of claim 5 or 6 wherein the encapsulating material is a thermoplastic material initially in its heated plastic state when fed into said mold cavities, said pairs of mold cavity-forming members being cooled, and one of said housings having a heated feed spout-forming portion opening onto a mold cavity-forming surface thereof, the end of which forms a heated continuation of the rest of the defining wall surfaces of the mold cavity involved which are cooled, said heated feed spout-forming portion keeping the encapsulating material therein in a plastic state, said material being instantly cooled and hardened when the mold cavity is filled therewith.

8. A miniature cartridge fuse comprising: a subassembly of an inner insulating housing, a fuse element disposed within said inner housing, a pair of conductive terminals at the opposite axial ends of said housing electrically and physically connected to the ends of said fuse element, and a conductive lead extending axially outwardly from said terminals; said subassembly being encapsulated by an outer encapsulating body of insulating material covering, sealing and physically extending between the exposed, exterior surfaces of said inner housing, terminal means and a portion of each lead adjacent to said terminal means and a portion of each lead adjacent to said terminal means, said inner housing made of a relatively weak transparent material,
and said encapsulating body being made of transparent material which is a much stronger material than glass and which prevents the external fracturing of the fuse under high overload conditions.

9. The cartridge fuse of claim 8 wherein said inner housing is made of glass and said encapsulation body is a transparent material.

10. The cartridge fuse of claim 8 or 9 wherein the leads pass through said terminal means and are anchored to the interior thereof, said inner housing is an open ended body, and said terminal means being cup-shaped end caps telescoping over the ends of said housing and anchored thereto by solder within the housing.

11. The cartridge fuse of Claim 8 having a length no more than about one quarter inch, and an outer diameter no greater than about 0.1 inch.

12. The cartridge fuse of Claim 8 or 11 wherein said fuse has a rated current of at least about 15 amps.

FIG. 1

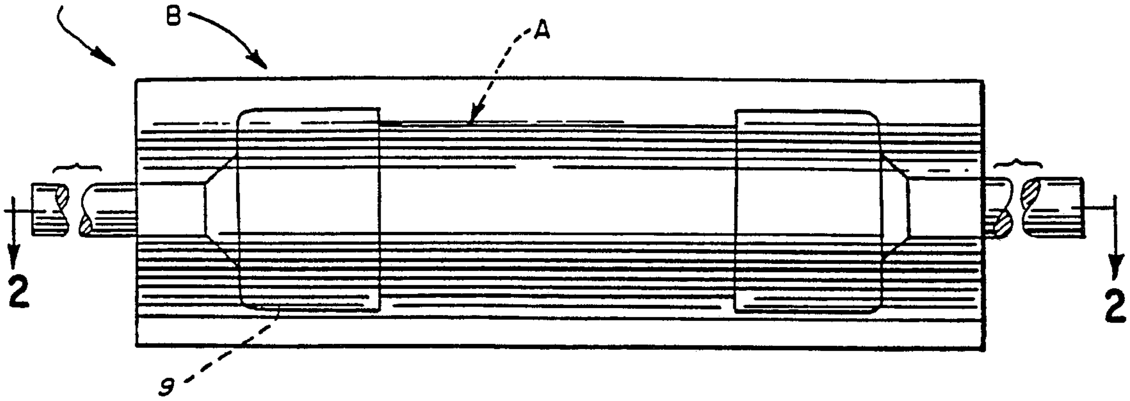


FIG. 2

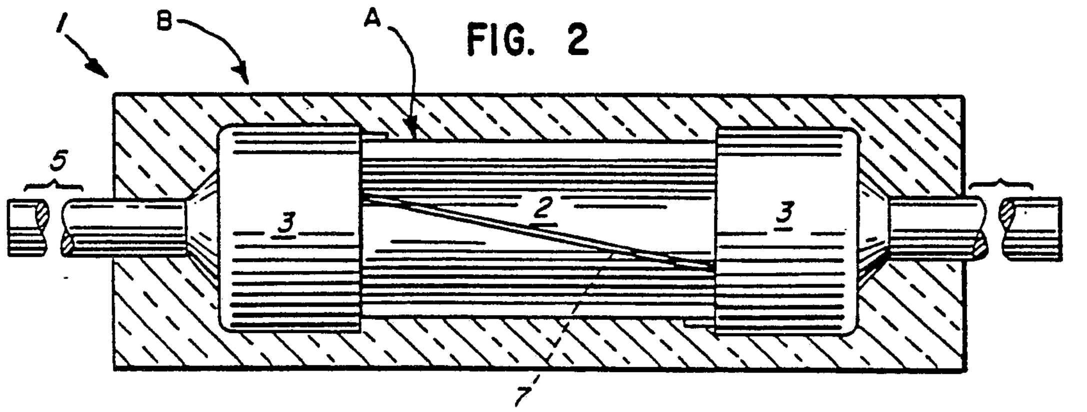
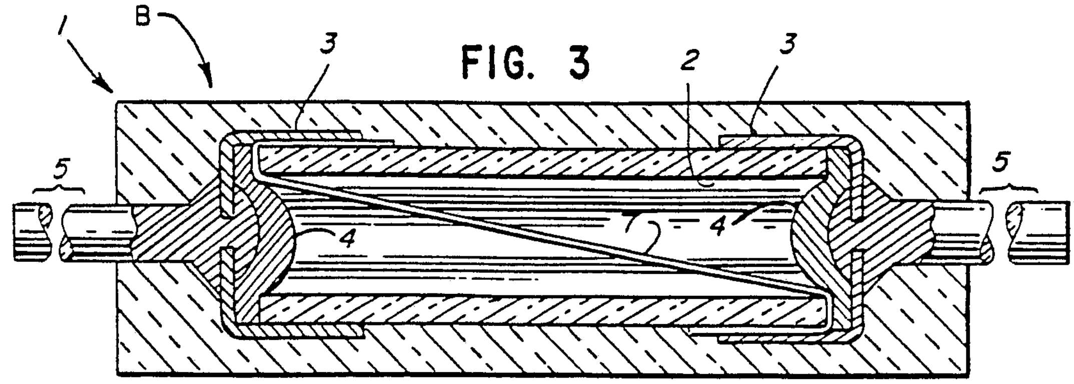


FIG. 3



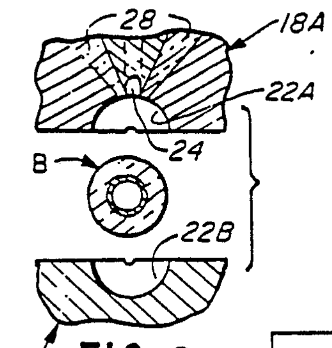


FIG. 6

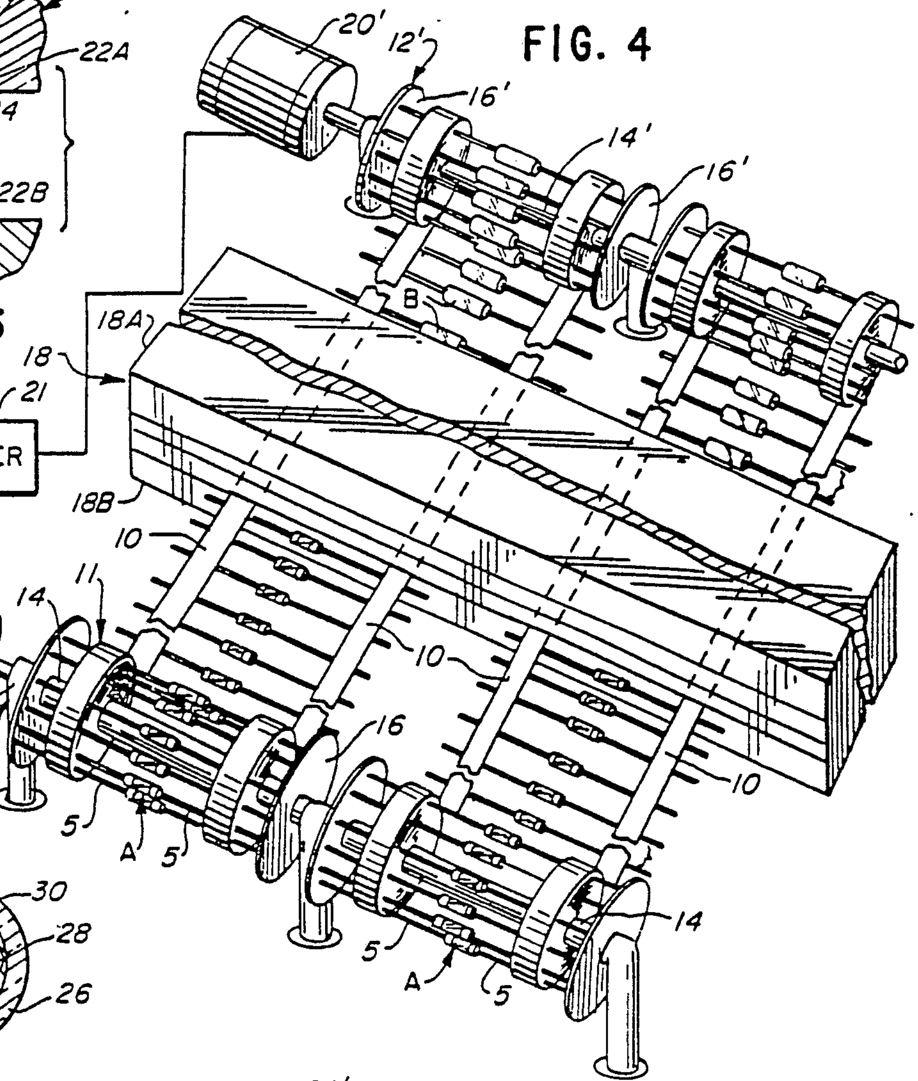


FIG. 4

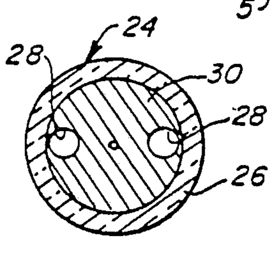


FIG. 7

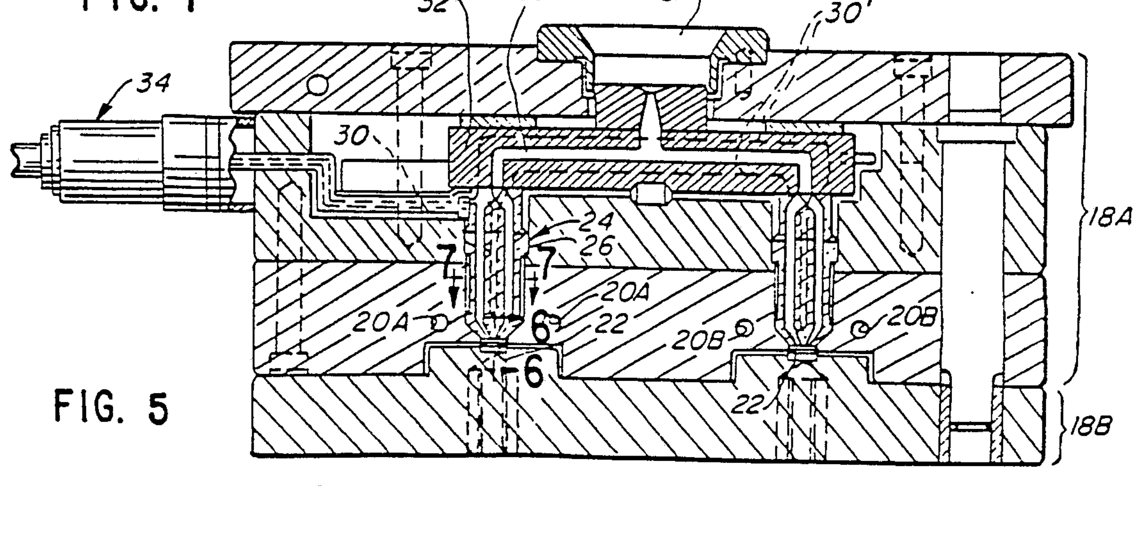


FIG. 5