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PROCESS OF MANUFACTURING A CHANNEL-MULTIPLIER PLATE

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FIG. 1

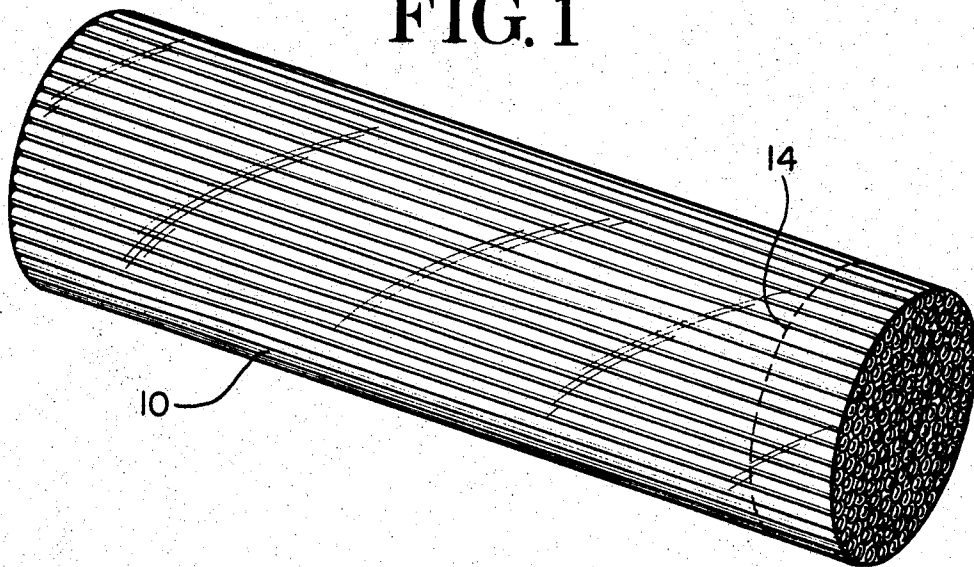
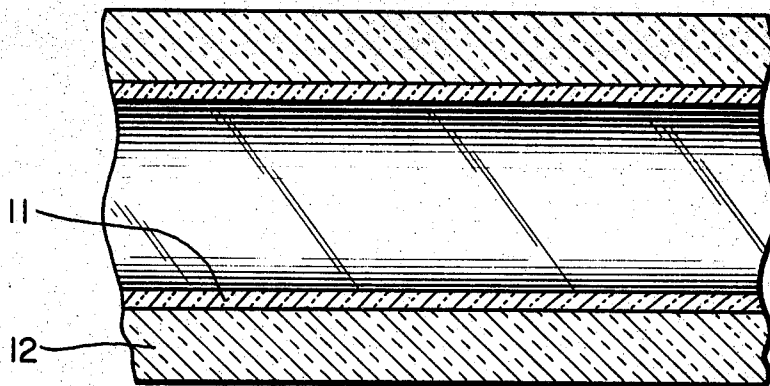


FIG. 2



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PROCESS OF MANUFACTURING A CHANNEL-MULTIPLIER PLATE

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3 Claims

ABSTRACT OF THE DISCLOSURE

A channel-multiplier plate has a multiplicity of channel elements individually having a hollow core that is soluble in an etchant and a superposed outer layer that is relatively insoluble in that etchant. One end of the channel plate is immersed in a bath of the etchant with the channel elements projecting above the surface of the bath. The dimensions of the channel elements and the properties of the etchant result in the channels filling with the etchant under the influence of capillary action. Thereafter, the plate is taken from the bath and the etchant dissolves the inner core of each channel.

BACKGROUND OF THE INVENTION

The present invention is addressed to the process of manufacturing a channel-multiplier plate and concerns most particularly the manufacture of such a plate comprising channel elements provided with an internal core throughout much of the fabricating process.

Channel-multiplier plates are quite well known and may be thought of as a type of electron multiplier. They are formed of a multiplicity or large number of channel elements frequently composed of fiber or glass tubing fused together to form a single integrated plate having a honeycomb type appearance. The channel elements are processed to have good secondary emission properties, and electrodes in the form of an aluminum coating are placed on opposing faces of the plate to facilitate the application of the necessary energizing potential thereto. In operation, if an electron image is focused upon the input of such a plate, electrons enter the individual channel elements and per force of consequent impact with the walls of the channels, the electrons effect a multiplication so that a multiplied or intensified electron image is produced at the output of the plate. The intensified image, in turn, impinges upon a fluorescent screen which converts the electron image into a light image. As thus far described, the structure and operation of the channel multiplier are extremely well known.

The art of preparing a channel-multiplier plate is indeed difficult because the individual channel elements are dimensionally very small. It is customary to start with a bundle of fibers or tubular elements which are then raised to the fusion temperature to integrate with one another and the resulting bundle is drawn to arrive at a desired final channel diameter. The drawing may be accomplished in one or more steps, but in any event, when the tubing has been drawn and attained the desired size, slices are cut from it. Each slice is useful as a channel-multiplier plate.

In order to increase the mechanical strength of the individual fibers to avoid channel distortion at any of the processing stages, it has been proposed that each channel element be constructed with a relatively heavy wall section. Various structural approaches may be adopted. For example, the tubing may be constructed of a single homogenous material of a chosen wall thickness or alternatively it may be formed of an inner and hollow core of one material with a superposed outer layer or cladding of a different material. Where this laminated structure is used, the significant difference in the materials of the in-

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ner and outer layers constituting a single channel element is in their softening temperatures and their reaction to a chemical etchant. Whatever form of channel element be employed, after the channel plate has been prepared it is necessary to reduce the wall dimensions of each channel so that a desired or optimum channel diameter is attained and this is most easily accomplished by etching away the inner wall. If the inner layer of a two-layer channel element is relatively soluble in an etchant while the outer layer is relatively insoluble in that etchant, this may be accomplished by circulating a suitable etchant through the channel elements.

A channel-multiplier of the type in question is the subject of U.S. Pat. No. 3,275,428 issued on Sept. 27, 1966 in the name of W. P. Siegmund and reference may be had to that publication for acceptable and illustrative processing steps relating to the fabrication of the tubular bundle or microboule from which slices are cut to serve as individual channel multiplier plates. In the reference patent, the inner core of the individual channel elements is dissolved by placing the channel plate in an etchant bath and utilizing a pump or other system for forcing the etchant to flow axially through the several channel elements of the plate. While this procedure would appear to be satisfactory, there is proposed herein a simplified process, particularly in relation to dissolving the inner portion or core of the channel elements of a multiplier plate.

Accordingly, it is an object of the invention to provide an improved process for the manufacture of a channel-multiplier plate.

It is a specific object of the invention to simplify the manufacture of such a plate having channel elements which, at least initially, are constructed with an internal but hollow core.

SUMMARY OF THE INVENTION

The process of the invention for the manufacture of a channel-multiplier plate comprises forming a plate of a multiplicity of similar channel elements of a predetermined length and individually having a hollow inner portion or core of a material which is wetted by and soluble in a predetermined etchant. This plate is then partially immersed in a bath of the etchant with a predetermined portion of its channel elements projecting above the surface of the bath. The internal diameter of the inner portion or core and the length of the projecting portion of the several channel elements are dimensioned in relation to the density and surface tension of the etchant to the end that the channel elements substantially fill with etchant under the influence of capillary action. The plate with its channel element thus filled is removed from the bath and the etchant entrapped within the channel elements is permitted to at least partially dissolve the inner portion of the channel elements. Thereafter, the etchant is removed from the channel elements.

In a preferred embodiment of the invention, the concentration of the etchant is selected so that the etchant becomes saturated when the core of the channel elements in which the etchant is trapped has been dissolved a preselected amount.

BRIEF DESCRIPTION OF THE DRAWING

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 represents a microboule which may be sliced to form individual channel multiplier plates; and

FIG. 2 is an enlarged fragmentary cross-sectional view of one of the channel elements of such a plate.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the manufacture of a channel multiplier plate in accordance with the invention, the first processing steps are conventional and may, by way of illustration, be as disclosed in the Siegmund patent to arrive at the microboule of FIG. 1. Since this part of the process is known, and of itself constitutes no novelty, it will be described only succinctly. The first step, of course, is to assemble a series of fibers of tubular elements of a fusible material, such as glass, in a mold by means of which they are conveniently brought to their fusion temperature and form a honeycomb type of structure as a result of these elements fusing to one another. The fibers have an initial diameter that is large compared with the ultimate channel diameter desired for the multiplier plate and, in order to enhance their mechanical strength, each fiber has a larger wall thickness than is to be exhibited by the channels after complete processing.

As indicated above, each fiber has a center channel or is hollow and may be formed of a single material although it is preferred that the individual elements have the structure represented in FIG. 2 with an inner core 11 of a material that readily dissolves in a chemical etchant and superposed over this core another layer or cladding 12 of a material that is relatively insoluble in the same chemical etchant. It is also desirable that the softening temperature of core 11 be higher than that of cladding 12 so that the core is able to retain the desired channel configuration even in the presence of high operating temperatures required to fuse the cladding layer of contiguous fibers together.

After the microboule has been formed, it is again brought to a high temperature to facilitate drawing the microboule in order to reduce the diameter of its fiber elements until finally the structure of FIG. 1 is attained having a multiplicity of fiber elements fused together and drawn to a desired channel diameter. It may then be sliced, as indicated for example by cutting along broken-construction line 14, to yield a channel-multiplier plate.

This plate is then processed as required to remove an inner portion or the core of each fiber element to attain an internal channel diameter of optimum size. In accordance with the invention, this is accomplished by immersing the plate in a bath of the etchant with one end in the bath and the remaining portion of the plate, and of course its channel elements, projecting above the surface of the bath. The internal diameter of the channel elements and the length of the portion of those elements projecting above the surface of the bath are dimensioned relative to the density and surface tension of the etchant to have the channel elements substantially fill with the etchant due to the influence of capillary action. This dimensioning of the channel elements is determined in accordance with the following equation:

$$h = \frac{kT \cos \theta}{rdg} \quad (1)$$

in which: h is the height of the channel elements above the surface of the bath; r is the internal radius of each channel element; T is the surface tension of the liquid etchant; θ is the angle of the meniscus formed by the etchant within a channel element; d is the density of the etchant, and g is the force of gravity.

Preferably, the parameters of Equation 1 are chosen to the end that under the force of capillary action the etchant essentially completely fills all of the internal channels of the elements defining the channel plate and then surface tension retains the etchant therein. Accordingly, the plates can and in fact are removed from the bath with the etchant entrapped in its several channel elements. The plate is then stored, for example on a beeswax coated

dish, to permit the etchant to at least partially dissolve the core of the channel elements. In the preferred practice of the invention, the concentration of the etchant is selected so that the quantity entrapped within a channel element becomes saturated when core 11 of the channel element shall have been dissolved. Where this condition is satisfied, it is not necessary to critically control the period of time over which the etching process is carried out since, by definition, the saturated etchant will have been exhausted or lost its effectiveness further to dissolve the channel element.

When the inner portion of each channel element has been dissolved to the point desired, whether that be accomplished in the preferred step of attaining saturation of the etchant or whether a stronger acid is employed and the etching is controlled in time to accomplish the desired result, it is necessary finally to remove the etchant from the channel elements and this may be accomplished by immersing the channel plate in a base solution to neutralize the etchant. Preferably the neutralizing solution is forced by pump action to flow through the channel elements and both neutralize and eject the etchant. Thereafter, the channel plate having elements that now contain the neutralizing solution is placed in an oven and dried at a temperature exceeding the boiling point of the solution, thus removing all of the fluid from the channel elements. At this juncture the individual elements of the channel will have the configuration of FIG. 2 except that core 11 will have been eliminated by etching. The etching step, resulting from the action of the etchant that has been trapped in the channel elements, is substantially uniform throughout the length of the channel element which is highly desirable because optimum results require that the channel elements be alike to one another and be uniform throughout their length.

Electrodes must be applied to opposite faces of the channel plate in order to facilitate the application of an operating potential across the channel elements. For this purpose, an aluminum coating may be applied over the end faces; generally this coating is applied by evaporation and penetrates the terminal portions of each channel for a length approximately equal to the channel diameter.

A channel multiplier plate processed in accordance with the invention may utilize channel elements of the type and dimension described in the aforesaid Siegmund patent. Where the elements are individually comprised of concentric components, the outer or cladding component may be composed of potash lead glass having a softening temperature of 600° C. while the inner or core component may be of soda lime glass having a softening temperature of 700° C. A chemical etchant suitable for dissolving the inner core is a 1% solution of hydrofluoric acid. Of course, the parameters must be in accordance with Equation 1 to assure that the etchant fills the channel elements under the influence of capillary action.

A channel multiplier plate prepared by means of the described process has the advantage that its outer cladding has a minimal exposure to the etchant. The process is further attractive in that it reduces the criticality of the etching schedule particularly where conditions are arranged to achieve saturation of the etchant when the inner core has become dissolved.

While a particular embodiment of the invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In the manufacture of a channel-multiplier plate the process which comprises:

forming a plate of a multiplicity of similar channel elements of a predetermined length, individually having a hollow inner portion of a first glass material that

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is wetted by and soluble in a predetermined etchant and further having an outer portion of a second glass material superposed over said inner portion, said second glass material having a lower softening temperature and being less soluble in said etchant than said first glass material;

partially immersing said plate in a bath of said etchant with a predetermined portion of all of said multiplicity of channel elements projecting above the surface of said bath, the internal diameter of said inner portion and the length of said projecting portion of said channel elements being dimensioned in relation to the density and surface tension of said etchant to have said channel elements substantially fill with said etchant under the influence of capillary action;

removing said plate from said bath and permitting said etchant to at least partially dissolve said inner portion of said channel elements;

and thereafter removing said etchant from said channel elements.

2. The process of manufacturing a channel-multiplier plate in accordance with claim 1 in which the concentration of said etchant is selected so that the quantity of etchant filling any of said channel elements becomes saturated when said inner portion of any such channel element has been dissolved a preselected amount.

3. The process of manufacturing a channel-multiplier plate in accordance with claim 2 in which the concentration of said etchant is selected so that the quantity of etchant filling any of said channel elements becomes saturated when said inner portion of such channel element has been substantially completed dissolved.

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