Nov. 30, 1965 | G. J. LILOIA ETAL | 3,220,409

FACE MASK

Filed March 28, 1961 | 2 Sheets-Sheet 1

Fig. 1.

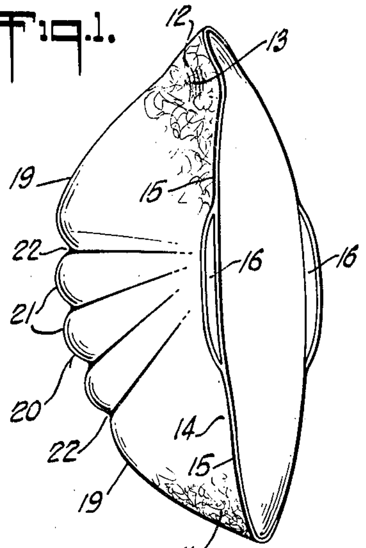


Fig. 2.

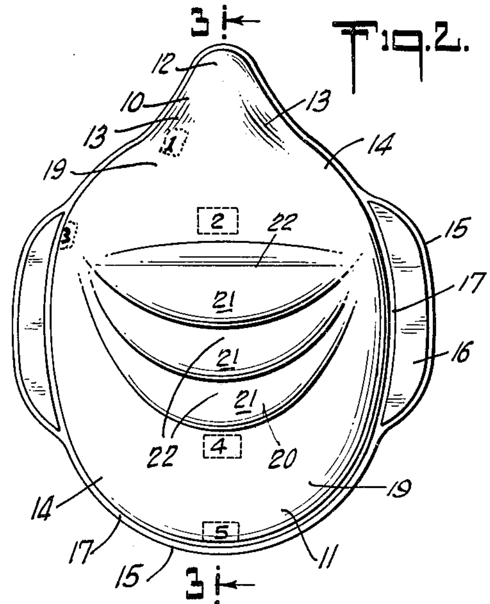
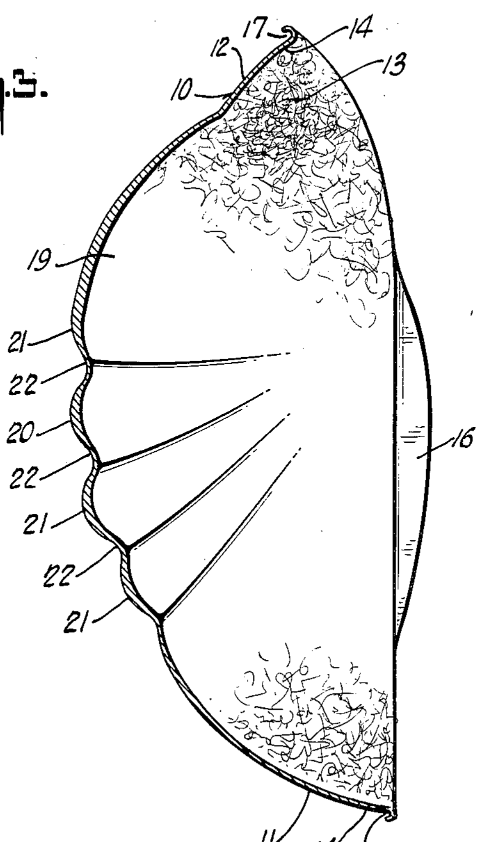


Fig. 3.



INVENTORS:
GERALD J. LILOIA
WILLIAM H. BIRD
BY Harold L. Warner
ATTORNEY

Nov. 30, 1965 G. J. LILOIA ETAL 3,220,409

FACE MASK

Filed March 28, 1961 2 Sheets-Sheet 2

Fig. 4.

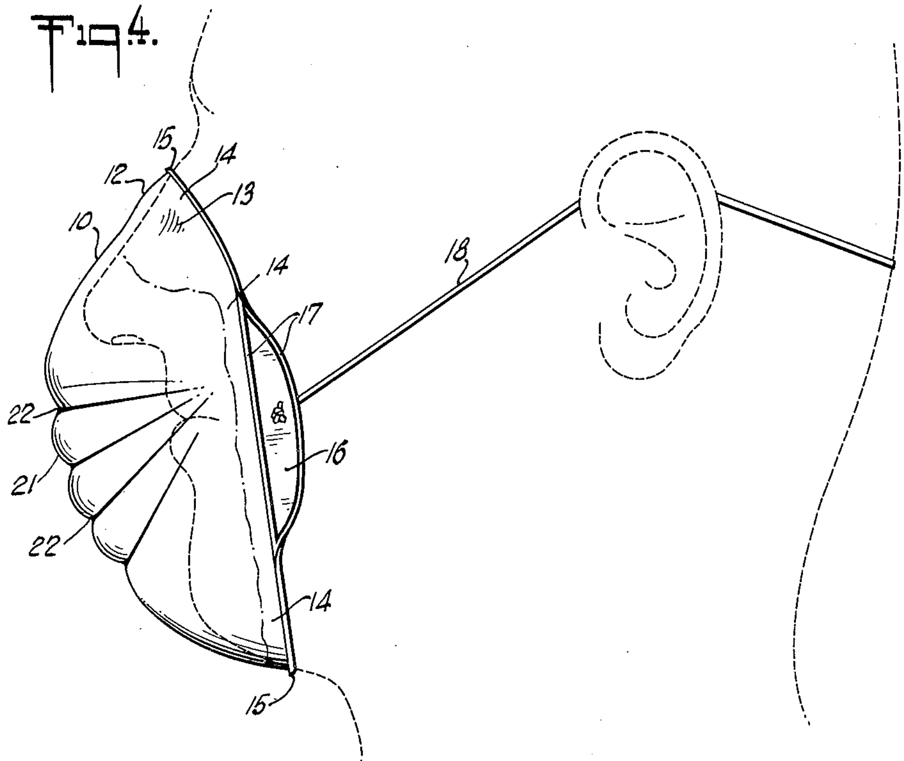


Fig. 5.

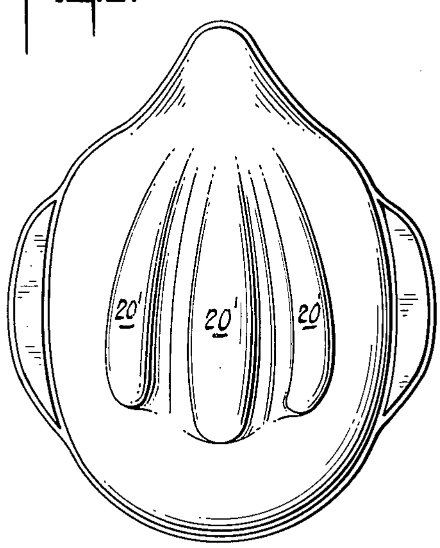
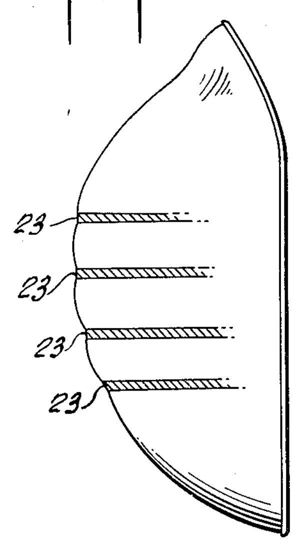


Fig. 6.



INVENTORS:
GERALD J. LILOIA
WILLIAM H. BIRD
BY
Harold L. Warner
ATTORNEY

United States Patent Office 3,220,409
Patented Nov. 30, 1965

3,220,409
FACE MASK
Gerald J. Liloia, North Brunswick, and William H. Bird, Bound Brook, N.J., assignors to Johnson & Johnson, a corporation of New Jersey
Filed Mar. 28, 1961, Ser. No. 98,903
13 Claims. (Cl. 128—146)

The present invention relates to face masks and more particularly to face masks having a high filter efficiency but which nevertheless can be manufactured at sufficiently low cost to permit disposal of the mask after having been worn but once.

Face masks of the present invention, although suitable generally for uses where high filter efficiency is desired, are particularly useful as surgical masks where the mask is to be used but a single time and then discarded. In surgery, it is the practice of the surgeon, attending nurses and others who are working with the patient to wear masks covering the nose and mouth to prevent or reduce, insofar as possible, infection of the patient or the wearer through air-borne bacteria. It is common practice to use for this purpose gauze masks which may take different forms and which are usually in the form of a gauze strip of several ply. The gauze mask is tied so as to cover the nose and mouth of wearer. These gauze masks are sterilized in the hospital autoclave or other sterilizing equipment which the hospital may have and, when placed on the face prior to the operation, are supposedly in a sterile state. These gauze masks are relatively expensive and are used repeatedly by the hospital because of their cost, being washed and sterilized between each use.

It is accordingly an object of the present invention to prepare a mask which can be sterilized but which also can be manufactured at a relatively low cost while still having a high filter efficiency. Since the possibility of respiratory type infections being transmitted to the patient is increased by wetting of the mask with saliva or mucous containing infectious organisms, it is a further object to form a mask which is maintained well away from the mouth and nostrils of the wearer and which is structurally stabilized so that it will maintain a preformed cupped shape. It is still a further object of the present invention to form a cupped structurally stabilized mask which, although having a high filter efficiency, offers very little resistance to air flow at the air velocities which are encountered with normal breathing so that air inhaled or exhaled by the wearer passes through the mask whereby it is filtered rather than passing between the edge of the mask and the wearer's face. Also, a mask offering very little resistance to air flow therethrough is substantially more comfortable to wear. Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings, wherein are set forth by way of illustration and example certain embodiments of this invention.

Referring to the drawings:

FIG. 1 is a persepective view of a mask made in accordance with the present invention;

FIG. 2 is a top view of the mask of FIG. 1;

FIG. 3 is a view taken along line 3—3 of FIG. 2;

FIG. 4 is an illustrative view showing the mask illustrated by FIGS. 1–3 as worn by a subject;

FIG. 5 is a mask with flutes extending over the cupped portion of the mask from top to bottom; and

FIG. 6 is a mask with reinforcing ribs but without flutes.

The mask as illustrated in FIGS. 1–4 has an upper portion 10 which is adapted to fit over the nose bridge of the wearer and a lower portion 11 which is adapted to fit around the wearer's chin. The upper portion 10 is formed

with a ridge section 12 which coincides with the top of the bridge of a wearer's nose and indented side sections 13 which are adapted to fit along either side of the nose bridge just above the nostrils to give a snug fit.

The rim portion 14 extends around the periphery of the mask and has its outer edge 15, which is adapted to contact the wearer's face, formed with a slight radius to provide good contact with the wearer's face without causing irritation which would occur if there were sharp edges. This curved edge extends around the periphery of the mask and also preferably extends as a U-shaped channel 17 along the base of the mask near the tab sections 16 to which attaching strings 18 would be secured. Through the use of this curved edge, a good seal can be obtained between the mask and the face of a wearer so that there is no leakage of inhaled and exhaled air around the edge of the mask with the result the air passes through the mask and is filtered.

The main body 19 of the mask is cupped out from the rim and is the portion of the mask designed to filter the exhaled and inhaled air. In order to increase the filter area, this portion of the mask is preferably formed with flutes 20 having peaks 21 and valleys 22. In the preferred construction, which is shown in FIGS. 1–4, these flutes extend crosswise of the mask and decrease in size as they approach the sides of the mask. The flutes are further formed so that they tend to spread out near the center portion of the mask and come together near the edges of the same. With this construction, more flexibility of the mask is obtained between the chin portion and the nose covering portion, making it somewhat easier to talk when the mask in in place.

The mask is formed of fibers which are molded together in the shape shown. These fibers may initially be in the form of a fiber batt or sheet which is placed between the dies for molding the mask, or the fibers may be floated down on top of one-half of the die before the second half of the die is placed thereon and the mask molded. The fibers have intermixed therewith a thermoplastic material which, in the preferred construction, is in the form of thermoplastic fibers which are blended together with the non-thermoplastic fibers to form the fiber body which is molded into the mask.

In order to obtain the maximum degree of strength while at the same time maintaining a high filter efficiency, the fibers are tightly compacted or compressed in the nose area 10, along the valleys 22 of the flutes, and in the rim area 14. The turned edge 15 and flanges 16 are also formed of tightly compacted fibers. This higher compression of the fibers in the areas indicated, with resulting greater compacting of the same, makes these particular areas stronger and somewhat more rigid than the areas in which the fibers have not been as tightly compacted, thus forming a strong resilient frame surrounding an area of fibers which are compacted to a substantially less degree. The degree of compacting substantially affects the resistance to air flow. Accordingly, a substantially lower resistance to air flow is obtained in these relatively lightly compacted areas. This gives a mask which has substantial structural strength but which at the same time has an extremely low resistance to air flow throughout most of the cupped portion 19. As a result, the mask so formed offers very little resistance to air flow while maintaining its molded shape. Accordingly, the air inhaled and exhaled by the wearer passes readily through the mask and at the same time a good seal is maintained around the periphery of the mask between the mask and face of the wearer.

By tightly compressing the fibers of the mask in the area 12 where it extends over the ridge of the nose of the wearer and in the areas 13 where it extends down along the side of the nose bridge, sufficient resiliency is obtained in the nose section so that it fits snugly around the bridge of a wearer's nose, making it unnecessary to use a moldable metal strip, as has heretofore been proposed, to obtain a snug fit in this particular area.

The mask of FIG. 5 differs primarily from the mask of FIGS. 1–4 in that the flutes **20'** extend lengthwise of the mask rather than across the same. The valleys of the flutes **20'** of the mask of FIG. 5 are compressed to a substantially greater degree than the ridges in a manner similar to that described in connection with the flutes **20** of the mask of FIGS. 1–4 so as to obtain the added structural strength which these relatively tightly compacted areas provide. Although in the mask of FIGS. 1–4 and in the mask of FIG. 5 the valleys of the flutes are more tightly compacted than the ridges, the fibers along the ridges could, if desired, be compacted to a greater degree than those in the valleys in which case the strengthening structural ribs would extend along the ridges of the flutes while the valley areas would act primarily to filter the air. However, it is preferred to have these structural ribs of more tightly compressed fibers extend along the valleys of the flutes, as illustrated in FIGS. 1–5.

Not only is the structural stability of the mask substantially improved by more tightly compacting the fibers around the base of the mask but this greater compacting of the fibers in this area substantially improves the resistance of the base portion of the mask to perspiration which is encountered while the mask is being worn. Without this greater compacting of the fibers at the base of the mask, the mask would be softened during wear due to wetting by perspiration. This would detrimentally affect the close fit between the mask and face with resulting leakage of air around the base.

The mask of FIG. 6 differs from the mask of FIGS. 1–4 and the mask of FIG. 5 primarily in that it contains no flutes. Also, the structural ribs **23** of tightly compacted fibers are spaced equally from each other throughout their entire length as they extend across the cupped portion of the mask.

The areas of greater compression in the mask are obtained by so forming the dies that there is substantially less clearance between the dies in the areas where greater compression is to be obtained. In the preferred practice of forming masks of the present invention, a mixture of non-thermoplastic and thermoplastic fibers are used. Synthetic fibers are preferably used as the non-thermoplastic fibers because of the uniformity in length and denier that can be obtained, viscose rayon fibers being preferred. However, other non-thermoplastic fibers, such as cotton and other natural fibers, may be used in place of the rayon fibers if desired. Any thermoplastic fiber may be used that would stand up under the temperatures to which the mask may be subjected during sterilization and storage. The thermoplastic fibers generally preferred in practicing the present invention are those sold under the trade-name "Vinyon," these fibers being formed of the copolymers of vinyl chloride and vinyl acetate. These Vinyon fibers generally melt at a temperature within the range of about 275° to 300° F., softening at a temperature of about 125° to 140° F., and becoming tacky at a temperature of about 185° to 215° F.

In the practice of the present invention, a web is first formed of a mixture of Vinyon and rayon fibers having a denier of about 0.5 to 5.5, the Vinyon and rayon fibers varying in ratio from about 10% by weight Vinyon fibers and 90% by weight rayon fibers to about 45% by weight Vinyon fibers and 55% by weight rayon fibers. The mask is then formed by placing the web of blended fibers within the die and compressing the same at a temperature sufficiently high to bond the thermoplastic fibers to the adjacent non-thermoplastic fibers. In the preferred practice of the present invention, the die is so formed that

the areas of the die in which the less compacted part of the mask is formed are spaced about 0.008 to 0.012 inch from each other for a web weight of 4 to 8 oz. per square yard when the die is fully closed and the remaining areas of the remainder of the die areas are in contact. In molding the mask, the web of fibers is subjected to an over-all die pressure of about 10 to 75 pounds per square inch, most of this pressure being placed around the rim, over the nose section, and along th ribs of the mask where the clearance between the two die members is substantially less than in the remaining part of the dies.

The high filter efficiency for air-borne bacteria of the masks of the present invention and the low resistance to air flow is well illustrated by the following table which gives the bacteria filter efficiency and resistance to air flow of masks formed of the same weight of fibers, the only change being in the proportion of viscose rayon fibers to Vinyon fibers used. The fiber batt used in preparing the masks has a weight of 7.43 oz. per square yard and the fibers have a length of about 1.5 inches and a denier of 1.5. The masks each have an area of approximately 27.83 square inches.

Mask	Fiber Formula	Bacteria Filtration Efficiency in Percent Bacteria Removal	Resistance to Air Flow, Inches Water Difference
1	80% Rayon, 20% Vinyon	82	0.15
2	75% Rayon, 25% Vinyon	87	0.27
3	70% Rayon, 30% Vinyon	86	0.222
4	65% Rayon, 35% Vinyon	86	0.237

Bacteria filtration efficiency is evaluated in vitro using a standard bacteria aerosol. The air resistance is measured at an air flow through the masks of 85.5 liters of air per minute.

It has been found that if masks formed in the manner described are sterilized in an autoclave and a group of the masks are sterilized together with one mask being superimposed over the other some sticking between the fibers of adjacent masks occurs at the relatively high temperatures of about 225° to 280° F. at which autoclave sterilization is generally done. Since the masks are primarily designed for use in hospitals where autoclave sterilization is generally used, it is highly desirable to avoid such sticking. It has been discovered that this sticking can be avoided by spraying the mask with a small amount of polyvinyl alcohol. It has also been found that with sterilization under autoclave conditions the porosity of the mask may be affected because of softening of the thermoplastic Vinyon fibers. The treatment with the polyvinyl alcohol has been found to stabilize the porosity of the mask under such sterilization conditions. Also, with masks containing from about 30% and less Vinyon fibers where there is substantial handling of the mask, there is a tendency for the surface fibers to become fluffed with the possibility that some of the fibers may become detached. This is undesirable particularly under operating conditions in a hospital. Also, the fluffed masks are substantially less comfortable to wear. The coating spray of polyvinyl alcohol has been found to bond together the surface fibers of the mask without having appreciable deleterious effect on the permeability of the mask so that the mask can be subjected to substantial handling without the surface fibers becoming loosened.

The polyvinyl alcohol coating is preferably applied by spraying onto the molded mask a water solution containing up to 10% by weight of the polyvinyl alcohol. Although polyvinyl alcohol is preferably used, other resin binders which are not softened at normal sterilization temperatures and which will deposit at the junctures of fibers in minute globules, as opposed to a continuous film, may be used. Among other materials that may be used for this purpose are, for example, methyl cellulose, hydroxy ethyl cellulose, polyacrylates, polyamides, and polyesters.

The following example, which is given for the purpose of illustration only and does not limit the invention, will help to better describe the mask manufacture.

Example

A batt of fibers comprising 25% Vinyon and 75% rayon uniformly blended is used. The fiber length of both the Vinyon and the rayon fibers is 1$\frac{9}{16}$ inches and the fiber denier is 1.5. This batt has a thickness prior to molding of about ⅛ to ¼ inch and a weight of 5.14 ounces per square yard. The fiber batt is placed in a mold having a female and male member which when engaged without anything placed therebetween touch in areas where greatest fiber compression is to be applied and are separated about 0.01 inch in areas where the least fiber compression is to be applied. The fabric is placed between the molds and the molds pressed together for about 2.5 seconds with a pressure of 65 p.i., the molds being heated to a temperature of 290° to 300° F. while the fabric is therebetween. The molds are then separated and the molded mask removed. Sections of the mask, as marked in FIG. 2, namely, sections 1, 2, 3, 4 and 5, are cut from the molded mask and tested for resistance to air flow which varies directly with the degree of fiber compactness. These areas give resistances such as shown by the following table:

Mask Section	Air Resistance to 8.5 Liters Air Per Minute Measured in Inches Water Differential—Area of Samples 0.25 Sq. Inch
	Inches
1. Nose area near opening of mask	0.50
2. Nose area near upper flute	0.35
3. Edge of mask near fastening area	1.15
4. Bottom area near last flute	0.27
5. Bottom area near opening of mask	0.68

When a mask similarly formed is placed on the face with tie strings extending around the back of the head to hold the same firmly in place, it offers little resistance to breathing. The mask has a bacteria filter efficiency for air passing through the same of about 82% and a resistance to air flow through the entire mask at 85.5 liters of air per minute in inches of water differential of 0.11 inch.

Although a wide range of fiber lengths may be used in preparing the masks of the present invention, it is generally preferred not to use fibers of less than ¼ inch because of the greater possibility of such fibers coming loose when the mask is in use.

Although the masks of the present invention have been described as being particularly suitable for surgical use, the masks may be used in any application where a mask of high filter efficiency and low air resistance is needed and are particularly suitable for use in those areas where inexpensive, disposable masks having high filter efficiencies are required. The invention is susceptible of many modifications within its spirit and accordingly is to be limited only by the scope of the appended claims.

Having thus described our invention, we claim:

1. A fiber mask comprising a raised cup shaped central portion adapted to fit over the mouth and nostrils of a wearer and having a relatively low resistance to the flow of air therethrough at air velocities comparable to those of normal breathing, a rim portion extending around said raised central portion and a nose-bridge-contacting portion, the fibers of said rim portion and nose-bridge-contacting portion being more densely compacted than the major portion of the fibers of said raised central portion and acting to strengthen said mask, said rim portion and nose-bridge-contacting portion being more resistant to the

flow of air and structurally stronger than most of said raised central portion.

2. An air permeable fiber mask having a raised, center portion adapted to fit over the mouth and nostrils of a wearer, ribs extending across said raised center portion and forming a part thereof, a nose-bridge-contacting portion and a rim portion extending around said mask and adjacent the outer edge of the same, the fibers forming said nose-bridge-contacting portion, rim portion and ribs being compacted to a substantially greater degree than the remainder of said mask and acting to strengthen the same, the center portion of said mask having substantially less resistance to air flow than said rim portion and said nose-bridge portion.

3. An air permeable mask of fibrous material comprising a raised central portion adapted to fit over the mouth and nostrils of a wearer and having a relatively low resistance to the flow of air therethrough at air velocities comparable to those of normal breathing, a rim portion, reinforcing ribs extending across said raised portion and forming a part of the same, and a nose-bridge-contacting portion, the fibers of said rim portion, reinforcing ribs and nose-bridge-contacting portion being compressed to a substantially greater degree than the fibers of said mask in said raised portion between said rim portion, nose-bridge-contacting portion and ribs, the center portion of said mask having substantially less resistance to air flow than said rim portion and said nose-bridge-contacting portion.

4. A mask of claim 3 in which the outer edge of said mask has an outward radial turn and in which the fibers of said outer edge are compacted to a substantially greater degree than the fibers in said raised central portion between said ribs.

5. A mask of fibrous material comprising a raised, central portion adapted to fit over the mouth and nostrils of a wearer, flutes extending across said raised portion and forming a part thereof, a rim portion and a nose-bridge-contacting portion, the fibers in said rim portion, in said nose-bridge-contacting portion and in the valleys of said flutes being compressed to a substantially greater degree than the fibers of said mask in said raised portion between said rim portion, nose-bridge-contacting portion and flute valleys, the center portion of said mask having substantially less resistance to air flow than said center portion between said flute valleys.

6. A mask of claim 5 in which said flutes merge together as they approach the rim of said mask and spread out as they approach the center of said raised portion.

7. A mask of claim 6 in which said flutes extend across said raised portion from one side of said mask to the other.

8. A mask of claim 2 in which said mask is formed of non-thermoplastic fibers bonded together with a thermoplastic material.

9. A mask of claim 8 wherein said non-thermoplastic fibers comprise at least 55% by weight of said mask.

10. A mask of claim 8 wherein 55% to 90% by weight of said mask is of non-thermoplastic fibers and the remainder of thermoplastic fibers.

11. A mask of claim 10 wherein said non-thermoplastic fibers are viscose rayon fibers.

12. A mask of claim 2 wherein said mask contains 55% to 90% by weight of viscose rayon fibers and 10% to 45% by weight fibers formed of vinyl chloride-vinyl acetate copolymers having softening through melting temperatures within the range of about 125° to 300° F.

13. An air permeable fiber mask having a raised, center portion adapted to fit over the mouth and nostrils of a wearer, ribs extending across said raised center portion and forming a part thereof, a nose-bridge-contacting portion and a rim portion extending around said mask and adjacent the outer edge of the same, the fibers forming said nose-bridge-contacting portion, rim portion and ribs being compacted to a substantially greater degree than

the remainder of said mask and acting to strengthen the same, the center portion of said mask having substantially less resistance to air flow than said rim portion and said nose-bridge portion, and the outer surface of said mask having an air permeable coating of polyvinyl alcohol.

References Cited by the Examiner

UNITED STATES PATENTS

2,173,781	9/1939	Gibello	128—141
2,376,871	5/1945	Fink	128—146
2,521,984	9/1950	Lang	55—514
2,548,942	4/1951	Brown	55—514
2,578,007	12/1951	Hill	128—146
2,720,477	10/1955	Lancaster	128—156
2,752,916	7/1956	Haliczer	128—146

FOREIGN PATENTS

780,709	4/1957	Great Britain.
780,710	4/1957	Great Britain.

RICHARD A. GAUDET, *Primary Examiner.*

JORDAN FRANKLIN, *Examiner.*