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3,333,585

COLD WEATHER FACE MASK

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FIG. 1

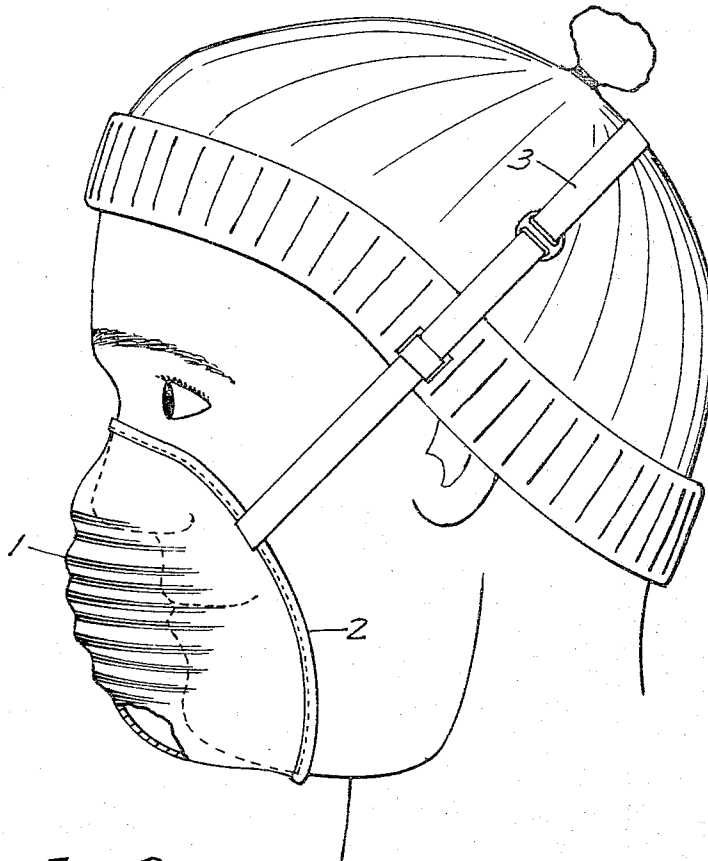
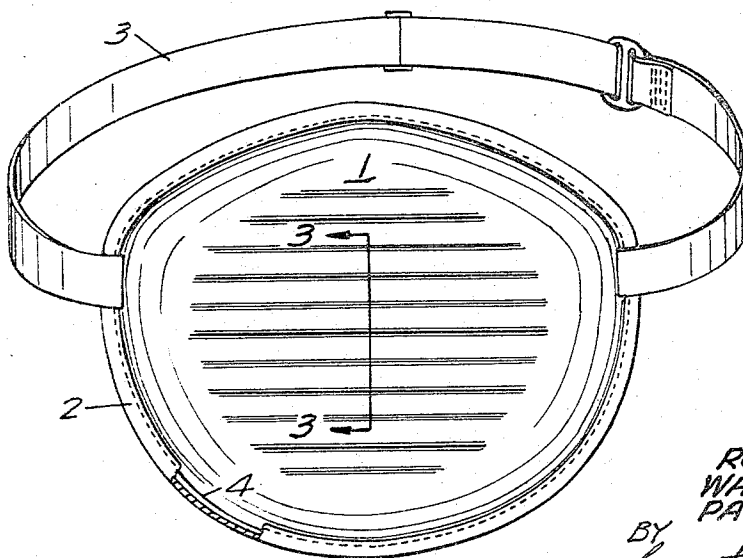


FIG. 3



FIG. 2



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COLD WEATHER FACE MASK

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1 Claim. (Cl. 128—212)

ABSTRACT OF THE DISCLOSURE

A heaterless self-sufficient cold weather face mask is formed of a shaped resilient nonwoven hydrophobic fibrous fabric which is breathably porous over substantially the entire frontal area and is cupped so as to stand out from the face away from the lips and nose. The entire weight with elastic head band is less than one ounce. Cold dry ambient air is autogenously warmed and humidified to a comfortable level before being inspired, even when at sub-zero temperatures as low as -30° F. or lower.

This invention relates to a novel cold weather face mask of shaped porous fibrous fabric that encloses the nose and mouth and produces autogenous warm air breathing even when the ambient air temperature is as low as minus 70° F. No electrical or other heating device is used.

As shown in the accompanying illustrative drawing, the face mask is essentially comprised of a light porous fibrous fabric having a rounded cupped shape. It is large enough to fit over the nose, mouth and chin in a non-constricting spaced-away manner, and can be conformed to make a fairly snug marginal fit such that breathing causes substantially all of the air to pass in and out through the porous fabric structure. This structure does not unduly interfere with breathing requirements of average persons engaged in moderately heavy work or exercise. The mask is comfortable and is retained by a light elastic head band. The entire weight including head band is less than one ounce. (The drawing will be referred to in detail later on.)

The heating process is autogenous in that in passing through the fine pores of the fabric the inspired cold dry air picks up heat and moisture that had been absorbed from previous exhalations of warm breath (which of course had received heat and moisture from the wearer's respiratory system). Condensation of water vapor in the fibrous structure releases heat. The fibers are maintained in a moist condition. Thus the porous mask structure functions as a heat exchanger and humidifier while exhaled air functions as a heat and moisture transfer medium. Some mixing of inspired air and exhaled breath occurs in the air space between the mask and the face; and not all of the air that is drawn through the mask is inhaled. A complex total system is involved.

Surprisingly, the present type of mask provides a self-regulating effect such that the inhaled warm air will have a temperature of at least about 60° F. no matter what the ambient cold air temperature is (down to -70° F.). The moist porous fabric structure is kept warm enough to prevent ice from forming and clogging the pores. The

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structure is such that the pickup of condensed water does not unduly restrict breathability through the mask nor cause the mask to collapse during inhalation. A porous mask is maintained that permits of comfortable breathing at all temperatures. Even under adverse conditions the mask will be operative for at least an hour, and ordinarily for several hours or more, before clogging up so as to require replacement.

Further advantages are that this mask protects the nose, chin and frontal face region from wind and frostbite and maintains a blanket of warm air thereover. It is compact, light and comfortable and does not interfere with facial movements required for comfortable speaking. It can be worn with heavy winter clothes. The mask is durable and it can be repeatedly rinsed or washed and dried for reuse so as to last for one or more winter seasons.

It is known that the upper respiratory tract both heats and moistens cold inhaled air and thereby protects the lungs and keeps moist the membranes that enable carbon dioxide excretion to occur. The colder the ambient air and the more rapid the breathing, the less efficient this natural process becomes even in normal persons, and especially in those having respiratory ailments. The colder the air the greater the respiratory energy demand and the greater the fatigue. This explains in part the value of breathing air which has been prewarmed. (Thus see paper of Walker and Wells in the American Journal of Medicine, issue of February 1961.)

Use of our mask enables persons working or exercising in freezing weather, and particularly in sub-zero weather, or in very cold refrigerated work areas, to be much more comfortable, to have a nearly normal breathing action without gasping or feeling constricted, to avoid overly stressing and burdening the heart and lungs, and to minimize irritation of the sinuses and the respiratory tract. The humidity of the inhaled air is held at a level which mitigates dehydration in the upper respiratory tract even at very low ambient air temperatures. Users can be more active and suffer less fatigue.

This mask is particularly valuable for persons who suffer from bronchitis, asthma, emphysema, sinusitis or angina pectoris. Some persons in this category are so sensitive to cold air that they have had to remain indoors during cold weather, unable to venture outdoors for even a short walk or "breath of fresh air" without suffering acute discomfort or pain or even endangering their life. It is well known that an attack of angina pectoris is likely to be brought on by walking or exercising on a cold day, and the colder the day the greater the risk. Medical study indicates that it is primarily the breathing of cold air, not the exercise, which precipitates such attacks. (Thus see article in Medical World News, issue of Apr. 26, 1963, at pages 35—36.)

This face mask has a broad field of cold weather application for adults and children who enjoy reasonably good health but who will be benefitted by the greater comfort, efficiency, endurance and healthfulness made possible by wearing the mask. Examples of outdoor workers who can benefit are mailmen, patrolmen, soldiers, linemen, railway yardmen, seamen, construction workers, newspaper delivery boys, snow shovelers, workers in refrigerated warehouses, etc. Outdoor recreation activities whose participants and spectators can benefit include skiing, ice skating, ice fishing, ice boating, sledding, hiking, hunting, parade marching, etc. Explorers, prospectors and

workers in arctic and antarctic regions, where atmospheric temperatures as low as -50° F. or lower may be encountered, can benefit greatly from using this mask. Temperatures below -30° F. are encountered during some winters in certain populous areas of the U.S.A., Canada, and Europe.

Surprisingly, the present mask also has utility as a hot air protective mask to lower the temperature of inhaled air substantially below that of the ambient hot air, to increase the moisture content and relative humidity of inhaled air, and to shield the nose and frontal facial region. In this case the exhaled breath has a cooling effect on the porous fabric mask structure. For instance, it has been found that persons exposed to ambient air of 140° F. will on the average inhale air of 100° F. when wearing the mask. This can be of real benefit to those exposed to very hot desert environments, particularly if they have been unable to become acclimated. The decreased loss of water from the body reduces the need for imbibing water. The mask can likewise be of value to industrial workers exposed to blast furnaces, glass furnaces, drying and baking ovens, boiler rooms, etc. In certain metallurgical shops workmen may enter tempering ovens maintained at 180° F. The present mask can lower the inhaled air temperature to 110° F.

Practical value and commercial utility for these cold air and hot air usages require a type of mask which is different in design and functioning from those face masks heretofore employed as filter masks for industrial, hospital or sanitary purposes to remove particulate matter from air that is inhaled or exhaled (dusts, mists, sprays and microorganisms). This will be evident from the foregoing discussion. Scarves, handkerchiefs, mittens, mufflers, fur pieces, gauze masks, and the like, have been employed, often out of desperation, to somewhat shield the face and act as a baffle to cause some warming of cold air (or in some instances cooling of hot air) that is inspired through and around such facial covering. It has been known that respirators are warmed by the breath and can temper cold air passing therethrough. Although these various expedients have been used for many years and some for centuries, they did not suggest the possibility of a simple featherweight face mask of the present type and utility, capable of an unpredictably high performance level over wide temperature ranges, and which combines a high degree of convenience, comfort and physiological efficiency with the durability and economy that make possible widespread use.

The unique performance of our mask results from and requires a combination of factors. The cupped-shaped fabric body of the mask should have an area in the range of about 25 to 35 sq. inches. The contour should enable the mask to extend out far enough from normal faces to avoid touching the end of the nose and tip of the chin. The edge margin should be pliable, soft and springy to permit of conformation over the bridge of the nose, under the eyes and across the cheeks, and under the chin, without uncomfortable pressure and without unduly restricting speaking movements of the lower jaw. Edge sealing action causes respiratory air to almost entirely pass through the porous mask rather than leaking around it. The so-called dead air space, enclosed between the mask and an average adult face, should be less than 250 cc. and preferably in the range of about 50 to 100 cc. The fabric body area of the mask should weigh less than 0.5 ounce. It should be so porous that 50 liters of air can pass through the mask per minute with an average pressure drop that does not exceed 0.1 inch of water (as measured by a precision water manometer).

A minor part of the total area of the body of the mask is made up of portions through which little or no air will pass during inspiration and exhalation, namely, the marginal edge portion, the portion under the chin and the portion around the bridge of the nose. The effective respiratory area is about 20 square inches when the

total body area is about 30 square inches for the mask shown in the drawing, i.e., is roughly 60% of the total. When the respiratory pressure drop of the mask is measured by a device wherein the mask is mounted in a manner that simulates mounting on a face, the pressure drop at 50 liters per minute is roughly 40% greater than when the air passes through the entire porous body of the mask. It is most convenient in commercial practice to measure the drop by a test procedure where air passes through the entire mask body and hence this pressure figure is used herein (as in the preceding paragraph) unless otherwise noted.

The foregoing parameters can also apply to face masks useful for certain other purposes, such as hospital filter face masks normally worn in temperate atmospheres. From lengthy experimentation we have discovered that certain further parameters are of critical importance to the success of our cold weather air-warming masks which function efficiently in sub-zero (below 0° F.) environments, namely:

(A) The fibrous structure must be composed of hydrophobic polymeric organic material, such as hydrophobic polyester and nylon fibers, acrylic textile sizing binders, and soft polyurethane fibrous foam structures (open or ruptured cells). These materials have a very low water absorptiveness as shown by the ability to quickly dry even after soaking in water. In contrast, cellulose fibers (cotton and rayon) are hydrophilic and water is readily absorbed within the body of the individual fibers. (This is true even when given a light sizing of an acrylic binder since the latter forms a thin discontinuous coating that is permeable to water.) Condensed water can tenaciously bridge across the pores when hydrophilic fibers are present so as to greatly decrease the respiratory porosity. The fibers become soggy and this further facilitates collapse of the mask due to suction force on the mask when inhalation is attempted.

(B) The respiratory fabric must have an adequate thickness and a type of pore structure (provided by inter-filar passageways) within which exhaled moisture can condense in order to provide sufficient heat exchange and humidification effects. Consistent with the presence of other structural factors this specific parameter is not satisfied unless the porous fabric body area is capable of a water pickup of at least about 10 grams. This can be ascertained by removing the edge binding portion of the mask and the headband, so as to free the body area. The latter is weighed, immersed in water such that it is thoroughly wetted, removed and allowed to drain for 20 seconds, and reweighed. The difference is the water pickup value, which is expressed in grams. Since the porous fibrous structure of the present mask is hydrophobic, there is very little absorption within the fibers. The pickup is almost entirely due to water filling the pores.

(C) The present mask remains breathable and does not collapse even when thoroughly wet, despite the water pickup ability just described. This can be strikingly demonstrated by immersing a mask in a bowl of water until the fabric is thoroughly saturated. The sopping mask is then removed and held for one minute to drain, during which it is given a half dozen vigorous shakes to free it of excess loose water. The wet mask is immediately mounted on the face and breathing is commenced. The first few breaths will free the pores so that thereafter normal breathing can occur. The low pressure drop, combined with the web stiffness of the rounded mask, prevents collapse. On the other hand, a similar mask containing a substantial proportion of rayon fibers when thus tested, could not be breathed through and it collapsed.

In the accompanying drawing which illustrates a preferred embodiment of the invention:

FIG. 1 is a side elevation showing the cupped-shape cold weather mask 1 as worn upon a face, making a snug low-pressure marginal contact between fabric and skin, and being conformed to the individual face so as

to extend over the nose bridge, under the eyes, across the cheeks and under the chin; the margin of the mask being flared to meet the face at a comfortable acute angle which provides a sealing relationship. The edge of the mask is covered by a bias fabric edging tape 2 to make a softer fit. The mask is held in place by a light elastic adjustable head band 3. In this figure a portion of the mask is cut away to show the thin porous fabric wall, which is stiff but flexible and springy so as to be comfortable and yet retain its shape and avoid collapse during inhalation. The fabric cup is corrugated to provide several horizontal ribs across the front, which further stiffen it and increase resistance to collapse. As shown by the dashed-line facial profile, the mask stands out from the face and does not touch the tip of the nose, the mouth or the chin, and it permits of adequate jaw movement for comfortable speaking and breathing through the mouth. As previously mentioned, the effective respiratory area of the mask is about 60% of the total area of the fibrous fabric body.

FIG. 2 is a frontal view of the mask as manufactured and before being fitted to an individual face. The edge structure (which is partially cut away in the figure) includes a bias cloth edging tape 2 extending over and around the edge of the body fabric, and conveniently held by stitching. This edging also covers and holds in place an edge loop of thin pliable wire 4, which renders the margin of the mask more conformable and enables it to retain its shape after being fitted upon the face.

FIG. 3 is an enlarged section taken on the line 3—3 of FIG. 2 and indicates in diagrammatic manner the ribbed or corrugated structure of the curved fabric which further strengthens and stiffens the frontal cupped body of the mask 1. It will be noted that the valley portions are thicker and hence less dense than the crests. This results from the molding process used in shaping the mask fabric as subsequently described. These and other areas which are least compressed, have a more lofty and porous structure that is advantageous to the breath-warming function of the mask and makes for easier breathing for a longer period. The more highly compressed tops of the ribs are less porous but are stronger on that account and this contributes to their utility as flexible stiffener elements.

This type of mask preferably has a one-piece seamless shaped porous fabric body which is nonwoven and consists of a compacted molded porous layer of randomly interlaced staple hydrophobic textile fibers. This shaped layer is unified by impregnation with a rubbery water-insoluble hydrophobic fiber binding sizing agent which thinly coats the individual fibers and bonds them together at their crossing points but without substantially reducing the porosity of the fabric. This combination of fibers and rubbery sizing provides a light, tough, washable, flexibly resilient, porous, fibrous fabric structure that can be designed in compliance with the mask requirements previously set forth.

Shaped nonwoven fabric mask cups can be economically manufactured on a mass production basis by employing fiber and sizing combinations, and molding procedures, consistent with the broad teachings of U.S. Patent No. 3,064,329 (Nov. 20, 1962).

Example

A preferred mask product and manufacturing procedure in accordance with the foregoing will now be described.

A mixture of three kinds of hydrophobic staple fibers, all having a length of about 1½ inches, is carded to form a fluffy batt weighing approximately 550 lbs. per thousand square yards. This mixture consists of 1 part nylon fibers of 15 denier size, 3 parts of the conventional drawn (oriented) type of polyester textile fibers (e.g. "Fortrel" or "Dacron" fibers) of 8 denier size, and 2 parts of undrawn (amorphous) polyester fibers of 3 denier

size. All fibers are unplasticized. A "Rando-Webber" machine (sold by Curlator Corp., Rochester, N.Y.) can be employed. The staple fibers are thereby randomly directed and interlaced into a loose fluffy web wherein the various types of fibers cross over and under each other so as to be held together in three demensions, the fibers being able to shift about in the subsequent molding operation to form a uniform layer having the desired cupped shape. This rather coarse fiber blends is well adapted to making the present cold weather mask.

The polyester fibers are made from a high molecular weight polyester of ethylene glycol and terephthalic acid, or equivalent. The drawn (oriented) fibers are chopped from continuous filaments formed from the melt by spinneret extrusion and drawing (stretching). The undrawn (amorphous) polyester fibers are produced in the same manner except that the drawing operation is omitted. The latter fibers have an inherent wide softening temperature range below the temperature at which they fluidity or melt, within which the thermo-softened tacky fibers can be autogenously interbonded at crossing points by application of light pressure, the fiber identities being retained. This initial softening temperature range is below the narrow melting range of the corresponding drawn fibers (which are crystalline). For instance, drawn fibers may have a melting point of approximately 480° F. (240° C.) whereas undrawn fibers of the same composition have a softening temperature range of approximately 200 to 450° F. (90 to 230° C.). The latter amorphous fibers, after heating to a tacky soft state, become crystalline on continued heating and harden and stiffen, with a loss of tackiness. (These characteristics are used to advantage in making the face mask; both types of polyester fibers being crystalline in the end product.)

This fluffy dry fibrous sheet is shaped over a gang of closely-spaced heated aluminum male molds maintained at a temperature (e.g. about 400° F.) in the thermosoftening range of the undrawn polyester fibers, the loose fibrous state permitting of conformation over the molds. These aluminum molds are contoured to bring about the ultimate desired ribbed cupped shapes in the molded mask bodies, and are preferably surface-treated with a release coating of a suitable fluorocarbon polymer (e.g., polytetrafluoroethylene) in order to guard against any sticking of fibers.

This shaped fluffy sheet is then promptly subjected to uniform soft-pressing against the heated molds to compact and unify it to a stable molded shape precisely conforming to the male molds. This pressing is effected by an overlying stretchy rubbery nonadhering blanket (such as a polychloroprene or silicone rubber sheet) in a frame, which is placed against the web-covered mold table. After 1 to 4 seconds for pre-heating, the intervening air is removed by suction to permit atmospheric pressure to push and shape the blanket against the mold. The molding time is about 20 seconds, after which the suction is released and the blanket promptly removed. The interposed hot molded fibrous sheet is immediately separated. There is no sticking or distortion and the sheet retains its shape during the further processing.

During the molding operation the undrawn (amorphous) polyester fibers fuse together at their crossing points. They then become nontacky and crystalline, and harden and stiffen. They do not adhere to the mold. They provide within the molded sheet an interlaced three-dimensional reinforcing and stiffening network, which unifies the sheet and enables it to be further handled without distortion. High-speed production is possible.

Upon cooling, the molded sheets are then impregnated with an aqueous dispersion of a hypo-allergenic rubbery acrylic polymer textile sizing latex which is applied by airless sprays to the outside and inside of the cups while moving on a conveyor. Impregnation is facilitated by the wicking action of the compacted fibrous structure and by inclusion of a wetting agent. The concentration of the

latex solids is chosen so that the fibers will be coated, and interbonded at their crossing points, without material loss of porosity. A "launderable" type of acrylic polymer is used, such as a carboxylic ethyl acrylate copolymer. These are well-known in the textile industry, and are self-cross-linking so that no external cross-linking agent need be used to obtain the ultimate three-dimensional polymer coating structure that resists repeated washing and prolonged contact with water and condensed breath vapor.

The following is a preferred formulation, parts being by weight.

	Parts
Latex dispersion of self-cross-linking "launderable" acrylic textile sizing polymer (46% solids) (e.g., "Rhoplex HA-16" sold by Rohm & Haas Co.)	37
Water	362
Wetting agent (e.g., "Triton GR-5" sold by Rohm & Haas Co.)	1
Sufficient dye to provide a desired coloration (e.g., a light beige color).	20

After saturation, drying and curing is accomplished on a continuous conveyor moving through an oven for 15 minutes at a temperature of about 350° F. The nominal acrylic resin content of the mask cups is about 17% by weight (dry basis).

The individual mask bodies are cut out and trimmed by die cutting. They are finished by providing around the edge a loop of pliable galvanized annealed iron wire (butt-welded) which is covered and held by a woven rayon bias edging tape which is folded over the edge and sewn in place. The ends of the adjustable elastic woven head strap are sewn in place before the edging is attached.

Any traces of the wetting agent present in the product are unnecessary and do not contribute to its performance. In fact satisfactory masks have been made wherein the acrylic polymer sizing treatment was followed by treating the fiber surfaces with a strongly hydrophobic fluoro-organic textile waterproofing agent.

In this embodiment, the total area of the mask surface is about 30 sq. in. The effective respiratory area (as previously explained) is about 20 sq. in. The total fiber content is in the range of 3.5 to 5.0 grams, and the weight of the impregnated molded mask body (exclusive of edging and wire) is in the range of about 4.2 to 6.0 grams. The total weight of the mask (including headstrap) is about 12-13 grams (less than half an ounce).

The mask provides a dead-air space between the mask and an average adult face of about 60 cc. The caliper thickness of the body fabric varies from place to place as already noted, due to the contour and to the molding procedure which results in varying compaction pressures. In the present case it has been found desirable to maintain a thickness of at least 20 mils in the frontal area below the ribs. In the corrugated or ribbed region, the thickness varies from about 25 to 50 mils at the extremities of the ridges, to about 30 to 110 mils in the intervening valleys, resulting in inwardly protruding lofty strips of highly porous fabric (as indicated in FIG. 3).

The air pressure drop at 50 liters per minute through the entire porous fabric body of the mask is in the range of approximately 0.035 to 0.065 inch of water (averaging about 0.05). In making this measurement, the mask is secured to a metal holder and fastened (convex side in) to the downstream end of a sheet metal pipe having a length of 15 in. and a diameter of 6 in. A precision inclined-tube water manometer is connected to a nipple in the pipe wall located approximately 1 in. from the tip of the mask. The air-flow into the other end of the pipe is held at the desired constant value by means of a flow-meter. The corresponding average value when air is permitted to pass only through the effective respiratory area of the mask is about 0.07 in. water.

The water pickup value for typical masks is about 15

grams. The mask is breathable and does not collapse even when thoroughly wet, as demonstrated in the manner previously described.

Laboratory tests on a number of subjects in a refrigerated room maintained at -20° F. demonstrated that this mask warmed the inspired air to at least 60° F., as measured by a rapid-response thermocouple positioned in front of the open mouth. In a hot room maintained at 170° F., the inspired air was cooled to at least 110° F.

This mask can be modified so as to decrease the tendency to fogging and icing of glasses that results from exhaled moisture penetrating the mask and rising upwardly to the cold lenses. This can be done by fastening to the upper periphery a curved strip of flexible waterproof plastic that projects outwardly and downwardly so as to extend above and beyond the tip of the mask. This vapor deflector does not contact the respiratory area of the mask. Improved edge sealing under the eyes can be effected by covering the combined upper edge structure with a thin rubbery compressible foam layer adhesive tape.

Example 2

A useful mask of the present general type can be constructed from sheets of soft rubbery low-density porous polyester polyurethane foam which has been processed so that the cell membranes are either absent or are eliminated by rupturing with a high pressure air jet applied to the foam layer. Such open-celled structure is fibrous in nature and very porous and can have a suitable pore structure for present purposes. A commercially available foam sheet which is one-fourth inch thick, having a density of about 1.5 lb. per cubic foot, has been satisfactorily employed. Two pieces of appropriate shape, die cut from the sheet, are sewn together at the front edge, such that when turned inside out a cupped-shape face mask weighing about 4 grams and having an area of about 30 sq. in. results. The mask is constructed such that it meets the essential requirements. There is no need for an edging or a peripheral wire. A wire or strip nose clip is attached on the outside in the nose area and is covered by an adhesively bonded strip of rubbery foam about 1/8 inch thick. An elastic headband is attached by fastening the ends to the mask.

This foam mask is very comfortable on the face and can be readily folded and carried in the pocket without damage. It can be washed easily by rinsing under a hot water faucet.

The pore size and pore volume are such that the mask can be worn in sub-zero weather for a long time without condensed breath vapor plugging it up or causing undue resistance to breathing.

Typical masks of this type have an average pressure drop when dry of only 0.022 inch of water at a flow rate of 50 liters per minute. This low pressure drop assures against collapse of the mask during inhalation despite its soft flexible structure. They have a water pickup value of 27 grams. These masks are breathable and do not collapse even when thoroughly wet, as demonstrated in the manner previously described.

We claim:

A cold weather face mask of the character described which is capable of being worn with comfort for extended periods to warm the breath to at least 60° F. even when the environmental ambient air temperature is below 0° F. and which is capable of repeated washing and reuse; the body of the mask being a nonwoven resilient porous fibrous fabric formed substantially entirely of hydrophobic organic polymeric material, having a cupped shape contoured so as to stand out from normal faces in spaced relation and to make a snug low-pressure conforming marginal contact over the bridge of the nose and across the cheeks and under the chin, the fabric weighing less than 1/2 ounce and being so porous that 50 liters of air per minute can pass through the mask with a pressure

drop of not over 0.1 inch water, the mask being breathable and not collapsing even when thoroughly wet and yet having a water pickup value of at least 10 grams.

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