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When most people hear the word, clothing, it is inevitable that they think of the fashion images with which the media bombards us every day. However, a great proportion of clothing worn by people all over the country today is worn not solely because of aesthetic or social reasons, but for physical ones. This clothing is worn for protection and safety. It is worn to improve people's health and well-being or to increase their capacity for work and enjoyment of leisure activities. It is this physical, protective aspect of clothing that leads me to define it as the "portable environment."

We exist in many environments and there are many levels at which protection can be achieved. Let's say, for example, that you owned a small company in the Arctic and you wanted an employee, a man, to be able to use tools and operate dials on equipment there, on a -30°F day. There are several ways you could help him accomplish his tasks. First, you could build a heated house or tent around him and the equipment so that he could work with bare hands. Second, you could change the equipment to be self-monitoring or design it to need less human control. For example, if a dial needed fine-tuning, it could be made to change in minute increments when you pressed on it so that the need for grasping could be eliminated. Third, you could create clothing that allowed the man to contact the equipment in a more effective way. He could wear a thin, electrically heated glove instead of the typically bulky Arctic mitten. A nonconductive knob could be built into his mitten so that he could grasp the knob from the inside of the mitten and plug it directly into a machine or directly into tools.

There may be situations where housing provides the best solution to a problem of personal protection and others where modification of equipment works best. However, I think that clothing holds tremendous possibilities for solving many of these types of problems, for several reasons. First of all, it is a "quick fix." That is, it is relatively inexpensive and quick to provide clothing rather than to build a house or make a modification in equipment. Let me give you some examples. I'll begin with a humorous one. There has been a lot in the news recently about snoring and some surgical and other medical procedures

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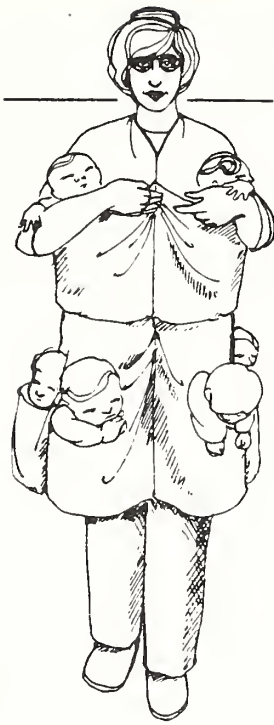


Fig. 1. Apron for emergency evacuation of an infant nursery.
(Design: Vera Leonard)

designed to cure it. Years ago, someone patented something called "anti-snore" pajamas. These were pajamas with a hard rubber ball sewn in the center back between the shoulder blades. When the snorer attempted to turn on his or her back, the rubber ball made the position too uncomfortable, so he or she returned again to another position -- one less likely to result in snoring! This garment provided a quick, simple, inexpensive solution to the problem.

Several years ago, a nurse in a maternity ward became concerned about how infants could be evacuated from a hospital in case of a fire. Her solution was not an expensive, elaborate vehicle, but a simple evacuation apron with baby-sized pockets so that each nurse could carry six infants to safety. (See Fig. 1)

As this last example illustrates, the money-saving aspects of a clothing solution to a problem can be significant. One field in which a clothing solution has saved billions of dollars is the microchip industry. When you or I walk across a carpeted floor, touch a metal object and get a shock, it is merely uncomfortable. When a worker in the microchip industry builds up a static charge on clothing or the body -- even one that does not result in a spark that can be seen or felt -- that worker's contact with a microchip may result in its contents being erased. Industry often attempts to control static by humidifying the environment or "grounding" as many factors in the environment as possible. One method that has been used to solve the problem is to place a conductive strap around each worker's wrist and essentially "chain" them to an electrically grounded work station. As you can imagine, this is not a very popular solution! Recently, materials have been developed that contain a small percentage of stainless steel (less than 2%). Red Kap Industries has developed a lab coat of a polyester/cotton/stainless steel material. Workers wearing this coat sit on a grounded chair at a grounded table. Electrical charges travel along the stainless steel filaments in the coat, so that they are dispersed over the whole surface of the garment and exit into the room rather than collecting in one surge to the hands when the worker touches a chip. This simple, inexpensive clothing item has solved a billion dollar problem.

Another reason why clothing is tremendously successful at solving problems of personal protection is that it stays with the body. The mobility that apparel gives you grants you a freedom to do things that would otherwise not be possible. The recent capturing of satellites by the Shuttle astronauts is the best example of this very special attribute of clothing that I can think of. There are many things you can accomplish in a hazardous environment,

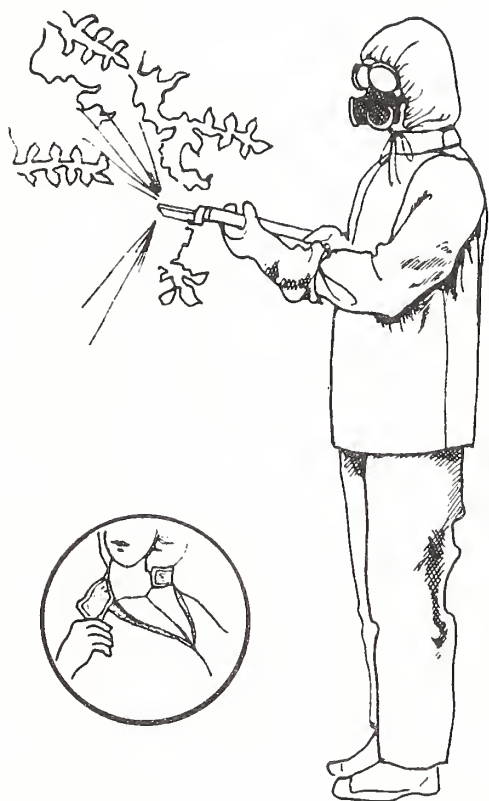


Fig. 2. Protective garment for pesticide spraying. (Design: Ellen Conti)

whether it be outer space, under the sea or on earth, that simply can't be accomplished as well by instrumentation or remote control. Butchers who want to be able to work directly with meat, rather than lose it to the recesses of a machine, wear gloves made of stainless steel mesh to protect their hands from sharp knives. This same steel mesh is used in suits that protect deep sea divers from shark attacks. These shark suits allow a mobility and freedom for exploration underwater that simply cannot be achieved in a cage or an underwater craft. Entry suits for firefighters have a similar advantage. They allow firefighters access to areas of the blaze that could not be approached in any other way. Garments for workers who spray pesticides protect the workers while allowing them to move close to foliage and achieve their purpose more completely than would be possible with machinery. (See Fig. 2.)

While mobility is of great importance, perhaps the reason why I feel that clothing is most important to personal protection is that it allows you to take maximum personal control over your life. It is not possible to change the environment in a way that makes everyone happy or indeed, is in everyone's best interest. Even something as simple as the temperature of an office is often a point of contention among workers. Clothing allows each individual to encase himself or herself in a personal, portable environment that establishes the kind of mini-world in which they want to live. So, you dress to stay warm if your office-mates prefer a cooler office or you wear rubber gloves when you work with potentially harmful household chemicals. This idea of personal control becomes even more critical when the environment seemingly moves more and more out of our control. The news is filled with conflicting articles about acid rain, nuclear waste, unsafe practices with pesticides and pollution--all of which leave us as

consumers uncertain of our personal safety. We've already seen the emergence of clothing items that protect us from hazards that were barely acknowledged years ago. The X-ray apron that you wear at the dentist provides one example of this. (See Fig. 3) Hospital gowns and masks that you wear visiting someone in quarantine are another.



Fig. 3. Leaded bib for a dental x-ray patient. (Design: Shielding, Inc.)



Fig. 4. A protective suit for "David," a child born with no natural immunities. (Design: NASA)

This decade has seen the emergence of many clothing designs that increase individuals' personal control over the environment. The mock space suit worn by David, the boy with no functioning immune system, is an excellent example. (See Fig. 4) This garment allowed David to leave his hospital "bubble" and enter a world that was normal for us, but potentially deadly for him. Functional accessories such as jewelry can also add this factor of personal control. One designer has created lifesaving jewelry. One of her necklaces monitors air quality and contains an oxygen mask that is released automatically when pollution or the pollen count becomes too high. (See Fig. 5) An asthmatic or highly allergic person would then have a five minute supply of oxygen which would allow them time to move to a safe area such as an air-conditioned building or car. This designer has also created a bracelet that monitors the pulse rate.

Another designer has suggested a smoker's hat. This is my favorite kind of functional clothing because other people wear garments that protect you. The smoker's hat contains a tiny motorized filter, much like those in some current "clean air" ashtrays, underneath its brim. Smoke is drawn into the filter as it leaves the smoker's mouth, and released out the top of the hat as cleaned, filtered air.

These items illustrate the potential for clothing and accessories to function to help the individual achieve maximum personal control over the environment. Yet, while I feel that that these portable environments we call clothing hold the key to personal protection, I would not want to leave you with the impression that clothing stands apart

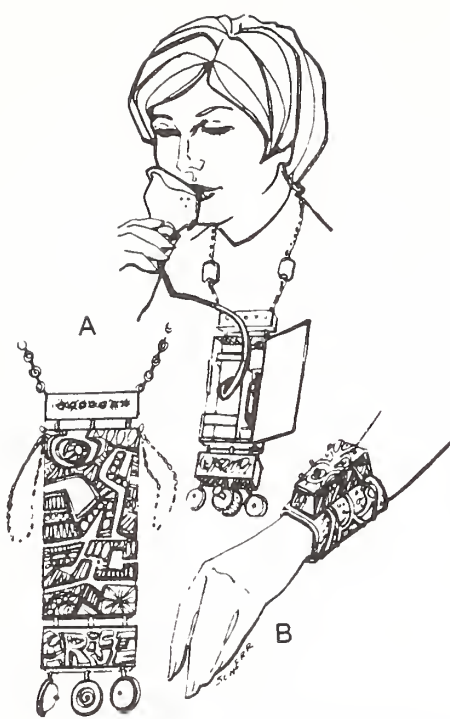


Fig. 5. Lifesaving jewelry. A: a necklace that monitors air quality and releases an oxygen mask when needed. B: a bracelet that monitors the pulse. (Design: Mary Ann Scherr)



from housing or other products in its attempts to protect the individual. Indeed, many of the most successful examples of personal protection can be found in solutions that combine all three approaches -- using housing, interior equipment and clothing to protect an individual. You have probably seen movies in which people who work with radioactive materials reach through rubber gloves that are a part of the wall of a chamber in which the hazardous materials are placed. A number of hospitals contain whole rooms that are sealed off in this manner to isolate immune-deficient patients such as those with leukemia. (See Fig. 6) Food, bedding and other goods are passed through sterilizing chambers on the wall of the unit. Hospital personnel put on vinyl garments, sometimes called "tunnel suits," that are actually part of a flexible wall of the room. These garments contain hook-ups for stethoscopes and other monitoring devices. A doctor, nurse or orderly can walk into the room and move around it, fully treating a patient or making up a bed, etc., without risking the patient's exposure to any non-sterile particles. In this design, the room, equipment and clothing all function together to solve a very complex problem of human protection.

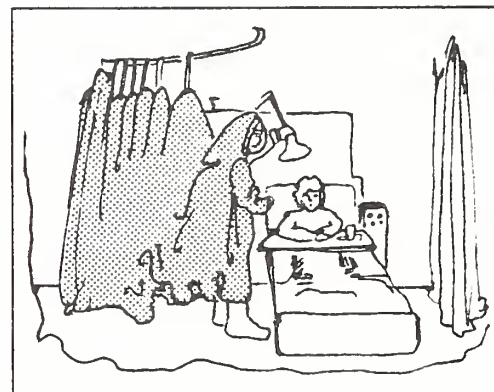


Fig. 6. A "tunnel suit" used in a germ-free isolation ward. (Design: AMSCO American Sterilizer)

A recent design competition sponsored by the University of Tennessee provides an illustration of the integration of housing, interior design, furniture, and clothing to solve thermal comfort problems related to solar housing. Two Cornell students submitted designs which extended furniture into body wraps and converted bedding, already warmed by the body at night, into dressing gowns for cold winter mornings. Open storage boxes recessed on the inside of the solar collection wall warmed garments and slippers that could be put on a person as he or she entered the house. Aluminized fabric screens were used to direct heat flow in the room or focus collected heat on the next day's clothing while the occupants of the house slept.

Although in both the hospital isolation ward and the solar house, all of the factors are interrelated, it is clothing that provides the greatest source of personal protection and personal control. It is clothing that makes the design solutions work.

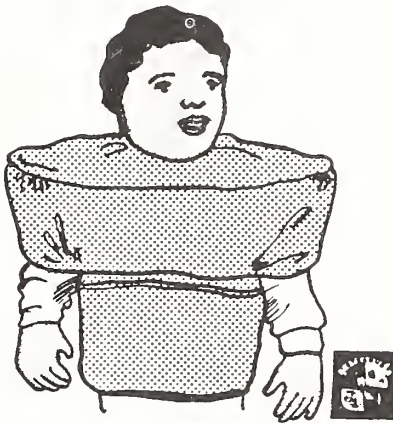


Fig. 7. The Kindergaard[®], a lifepreserver for infants. (Design: Stearns Manufacturing Company)

Advances in technology have made possible clothing for almost every imaginable occupation or recreational activity. Athletes are protected from injury by increasingly sophisticated sports equipment. A lot of the knowledge formerly used to protect the body after injury is now being used to prevent injury from occurring. Children have been the focus of considerable development in clothing and equipment for a wide variety of sports and recreational activities. For example, special life preservers have been developed for young children who may not swim, or who may panic in a boating accident. These safety devices have a large amount of flotation material just below the chin so that the face is always kept out of water regardless of the thrashing of the arms and legs as the child moves. (See Fig. 7)

Learn-to-swim bathing suits have also been created. One, for a little girl, contains a series of styrofoam wings which, when all are used together, allow a child to float. As a child gains confidence in the water and takes on a bit more flotation herself, individual floats are removed from the suit one at a time, until they are no longer needed. This type of design is a great improvement over the old sink-or-swim, inner tube approach to the problem.



Fig. 8. A police officer's bulletproof vest.

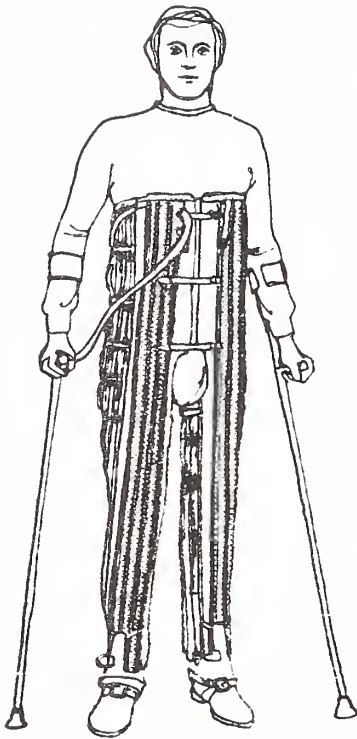


Fig. 9. The Orthowalk[®], a pneumatic, all-fabric support for paraplegics. (Design: ILC Dover)

There are countless other illustrations in the adult world as well. Policemen are now protected by bulletproof underwear. (See Fig. 8) Firefighters wear high visibility garments made of Nomex[®] or other aramid fibers that not only provide flame resistance but prevent heat from being conducted to the skin surface. This same heat-resistant fabric is used to increase the safety of race car drivers. In the past, the fire retardant cotton used in racing coveralls provided only about $2\frac{1}{2}$ seconds of protection from the high temperature flames that resulted from the fuels used in racing. When aramid fibers such as Nomex[®] began to be used in racing garments, the driver's time of protection (from the time the flame contacted the garment to the time the skin blistered) was lengthened to about 20 seconds. When designers began to experiment with these fabrics, even more protection time was provided. For example, one Nomex suit was fitted on its innermost layer with fine tubing. When a crash occurred, a driver could activate a foam-producing mechanism in the suit, and a stable heat-resistant foam flowed out of the tubing, filling the space between the skin and the garment. This foam remained stable for five minutes, greatly increasing the time the driver was protected.

The medical field is full of examples of the effects of advanced technology. There are inflatable, all-fabric orthotic (support) devices. One is shaped like a pair of pants but contains thin tubing extending down the length of the legs. (See Fig. 9) The tubing is inflated until it is rigid as a steel brace. This device allows a patient's limbs to be straightened as they would be with metal braces, but without the weight of metal or the stress that metal parts place on regular clothing.



Fig. 10. Feeding vest for a patient who has no stomach. (Design: Dr. Stanley J. Dudrick, 1979, "Vest for Ambulatory Patients Receiving Hyperalimentation, based on illustrations in Surgery, Gynecology and Obstetrics 148:588)

Another medically related item is a vest that has been developed for a boy who has no stomach. (See Fig. 10) The bags of food he needs to survive are kept in pockets on the vest and propelled by a tiny pump into a tube that leads into the body. With this garment, the boy is free to move around. Without it, he would be tied to hospital equipment. Knee braces, pressure garments for burn victims and anti-embolism stockings are only a few of the many clothing items designed to help increase the well-being of thousands of people.

There is no doubt that technological advances will continue in the coming decade. My feeling is that we will see more and more of a new type of protective clothing -- the kind that, like the automobile

air bag, eliminates the need for a wearer to "buckle up" or make any response at all to danger. The best example of this type of clothing that I can think of is a new type of logger's pants recently brought to this country by a company named Swedfor®. Current loggers' pants are generally bulky, quilted garments that are intended to give the logger a short margin of safety, generally less than a few seconds, to get out of the way of a chain saw. The new Swedfor® pants contain a multiple layered liner made of a fabric that actually prevents a chain saw from functioning. When a chain saw hits the liner fabric, strong threads are pulled out and tangle in the chain saw mechanism causing its motor to shut off. Thus, the wearer is protected even if unconscious or pinned under a tree. I think we will see many more examples of this kind of self-sufficient protective clothing in the near future.

One of my Cornell colleagues, Gary Sloan, is involved with office design. He says that the office of the future should not just be designed intelligently, it should BE intelligent. As we talked about clothing, it became clear to me that this was an apt description of clothing of the future too. It is conceivable that in the not-too-distant future we may wear garments that react to changes in posture, tension in muscles and other potential long range health hazards. These garments may automatically massage a tense muscle, prod the body into a correct posture, provide a burst of heat in areas where it's needed or stimulate the flow of blood to a specific body part. They may sense

hazards such as pollution or electrical charges in the air and emit compensating factors to form an intimate, personal, protective environment around each individual body.

There are already complex mechanical devices that allow a paralyzed limb to function essentially normally. I think we will see the development of garments that accomplish this same function while maintaining a normal, fashionable outward appearance. It is conceivable that clothing could be developed that would lock your body in a safe position when you are in a car crash or when you fall while skiing. We may, in the future, be wearing garments that are joined with biological seams that grow together again if they split, and expand or contract with weight gain or loss. My friend, Joann Boles, who teaches apparel design at the Virginia Polytechnic Institute, says that we may be choosing designs from an array of styles displayed on computers, pouring vials of material into their own personal body molds, putting the molds in our microwaves while we take showers, and stepping into newly-formed garment each morning. We may be warmed by garment made of heat-storing fibers and cooled by garments made of heat-absorbing ones. The groundwork for many of these developments is being laid right now.

To me, the most exciting part of the future of functional clothing is that many of these items will not just be for exotic environments like outer space or under the sea, but will be for a wide range of common occupations and leisure activities that will touch the lives of every household. They will increase the likelihood of having whole, healthy family members and will increase our capacities for enjoying full lives.

Figures are taken from Clothing: The Portable Environment by Susan M. Watkins, published by the Iowa State University Press, Ames, Iowa, 1984.