United States Patent [19]

Brody et al.

[11] **3,818,487**

[45] **June 18, 1974**

[54] **SOFT CONTROL MATERIALS**

[76] Inventors: **Warren M. Brody; Avery R. Johnson,** both of Armory Rd., Milford, N.H. 03055

[22] Filed: **Aug. 24, 1972**

[21] Appl. No.: **283,523**

[52] **U.S. Cl.** **340/407,** 137/247.17, 137/271, 137/468, 178/22

[51] **Int. Cl.** **G08b 1/00,** G08b 1/04

[58] **Field of Search** ...... 340/407, 365 A; 178/17 D; 235/201 PF, 201 R, 201 ME, 200 R

[56] **References Cited**

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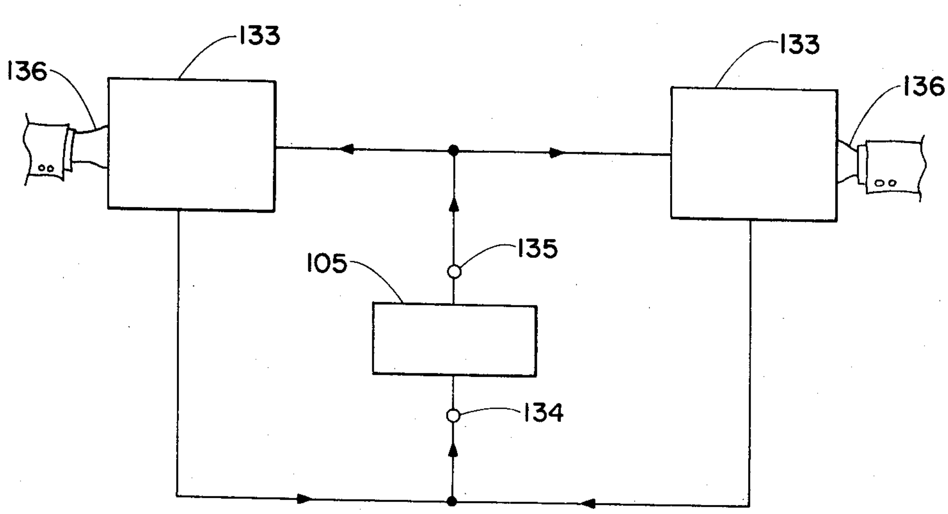
Primary Examiner—Thomas B. Habecker

Attorney, Agent, or Firm—Edward E. Pascal

[57] **ABSTRACT**

Soft control material usable as an interactive device with a user, or as a medium of communication between users on the tactile and least complex level. The material is self organizing; it uses distributed, self referent, and majority control of regions of the material, which allows greatly reduced amounts of information to be transmitted between units for communication therebetween. In its simplest form the change in total surface area of two adjacent bladders filled with Freon is detected as the individual bladder temperatures of the Freon increase or decrease to the boiling or condensing points.

25 Claims, 33 Drawing Figures



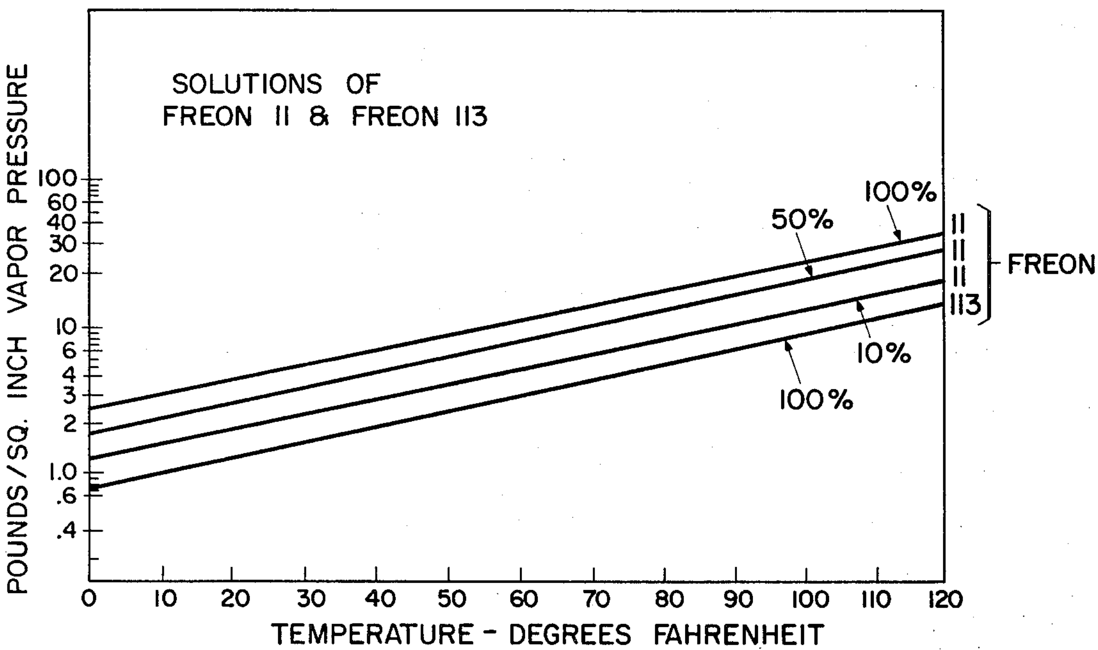


Fig. 1

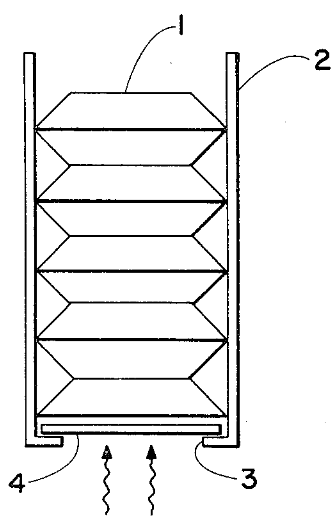


Fig. 2

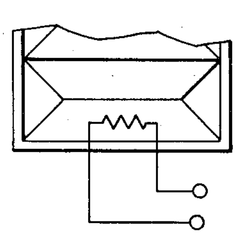


Fig. 2A

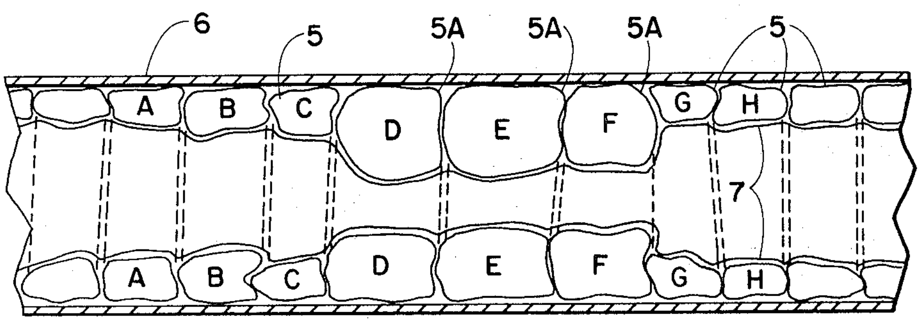


Fig. 3

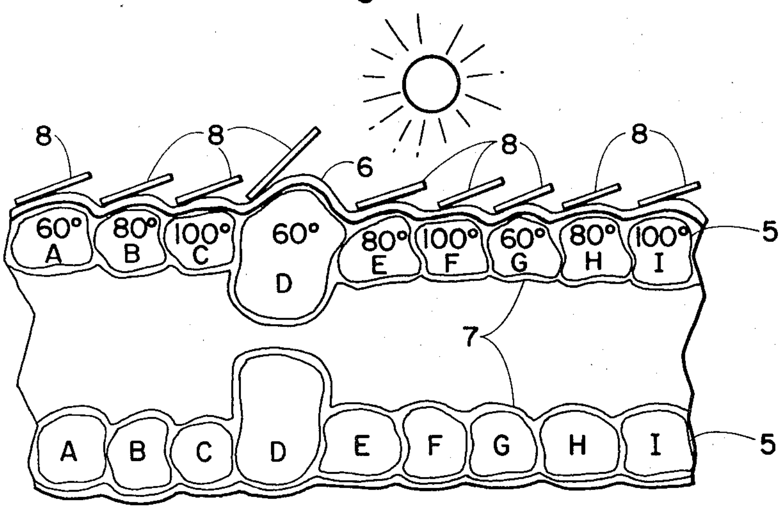


Fig. 4

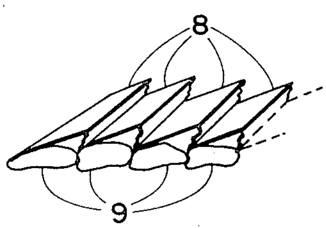


Fig. 5A

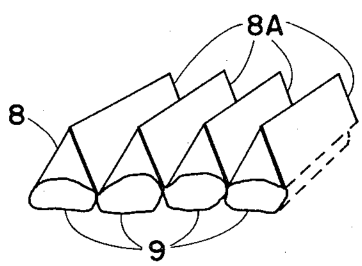


Fig. 5B

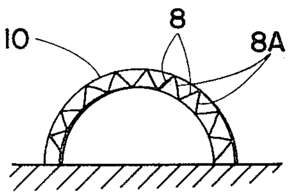


Fig. 5C

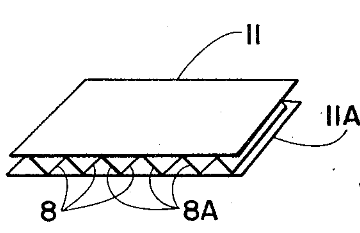


Fig. 5D

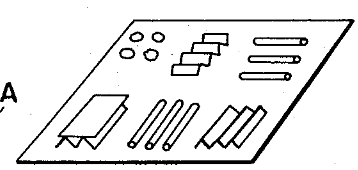


Fig. 5E

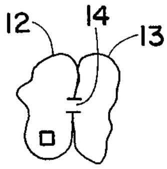


Fig. 6A

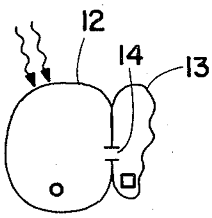


Fig. 6B

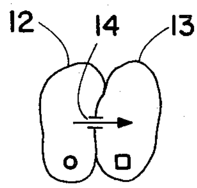


Fig. 6C

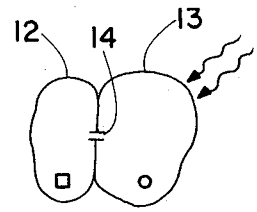


Fig. 6D

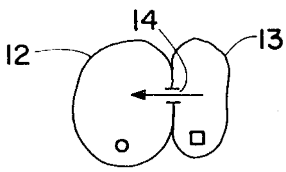


Fig. 6E

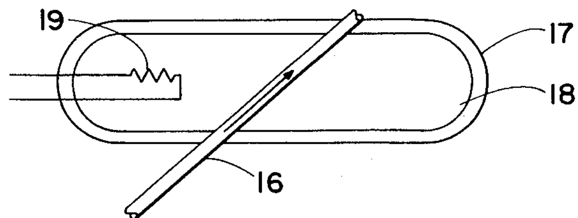


Fig. 7

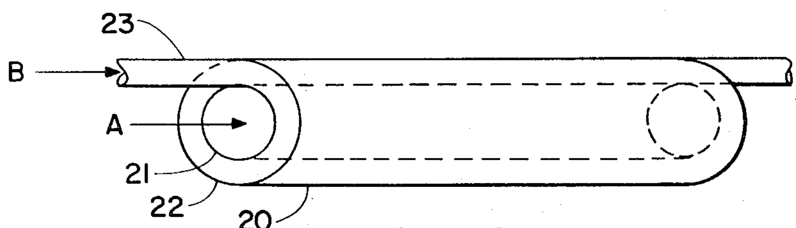


Fig. 8

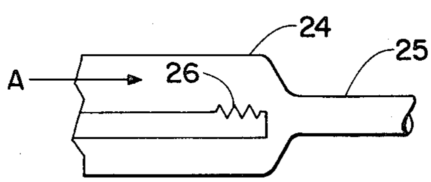


Fig. 9

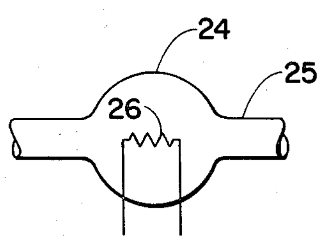


Fig. 10

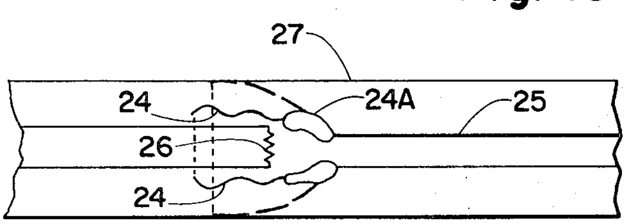


Fig. 11

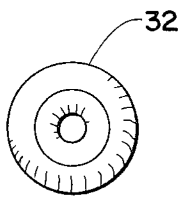


Fig. 12A

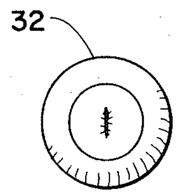


Fig. 12B

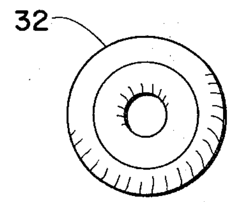


Fig. 12C

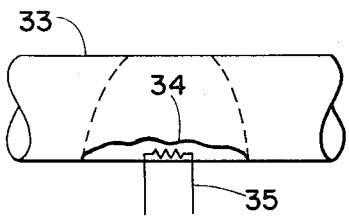


Fig. 13A

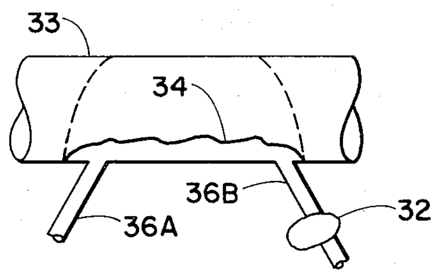


Fig. 13B

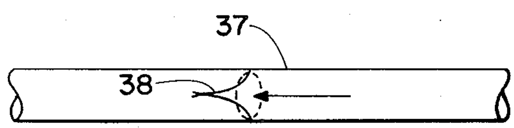


Fig. 14

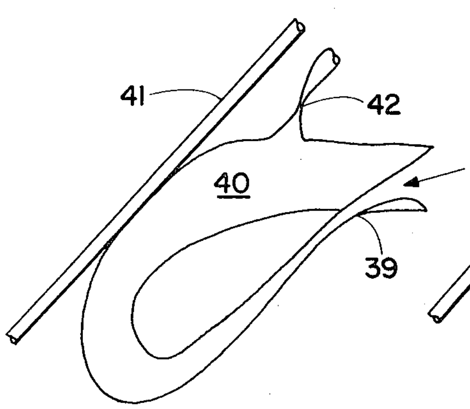


Fig. 15A

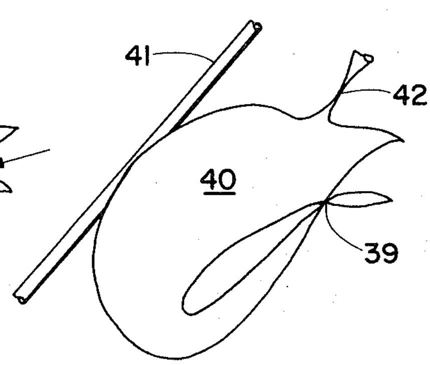


Fig. 15B

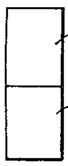


Fig. 17
Fig. 18

Fig. 16

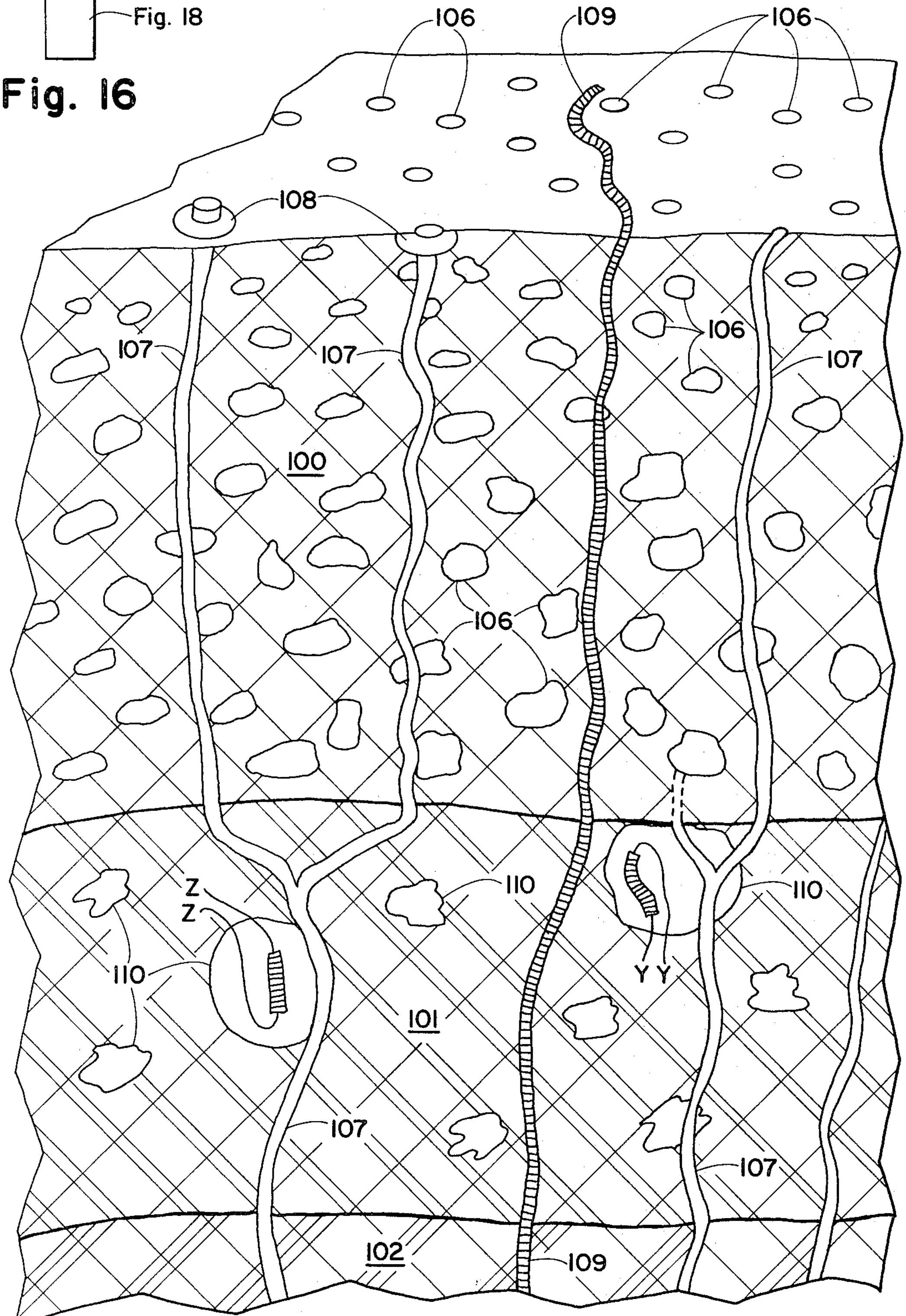

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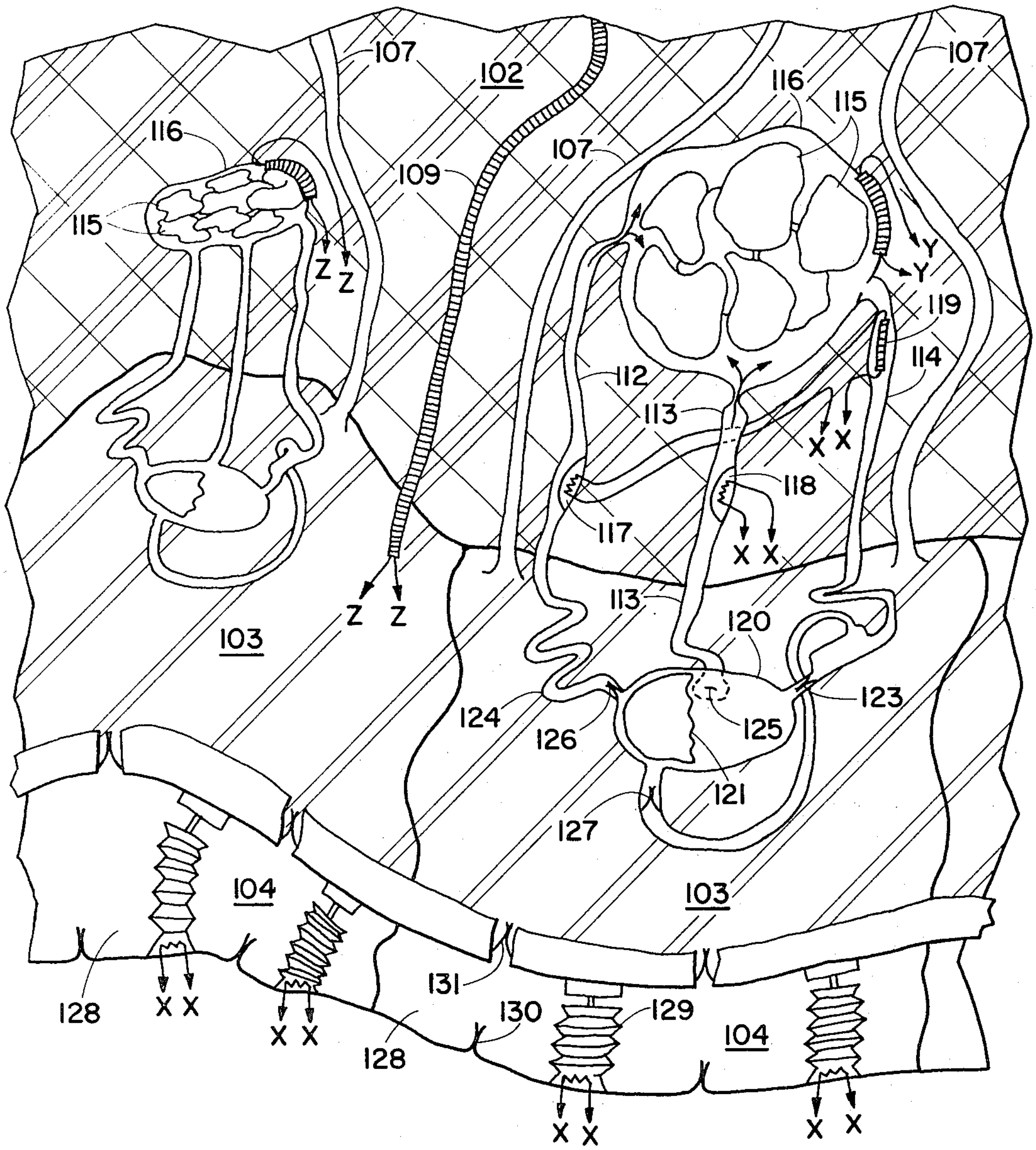
Fig. 17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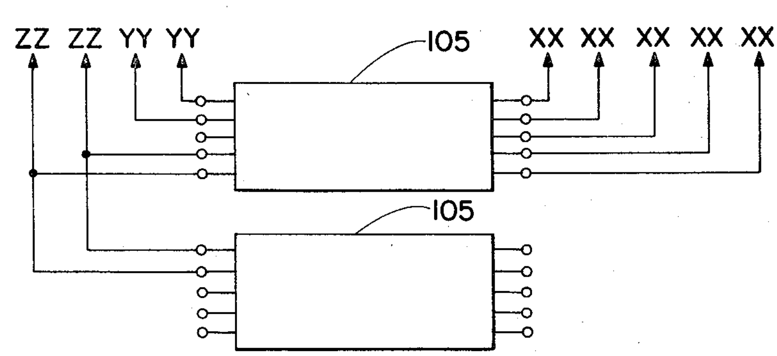
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Fig. 18

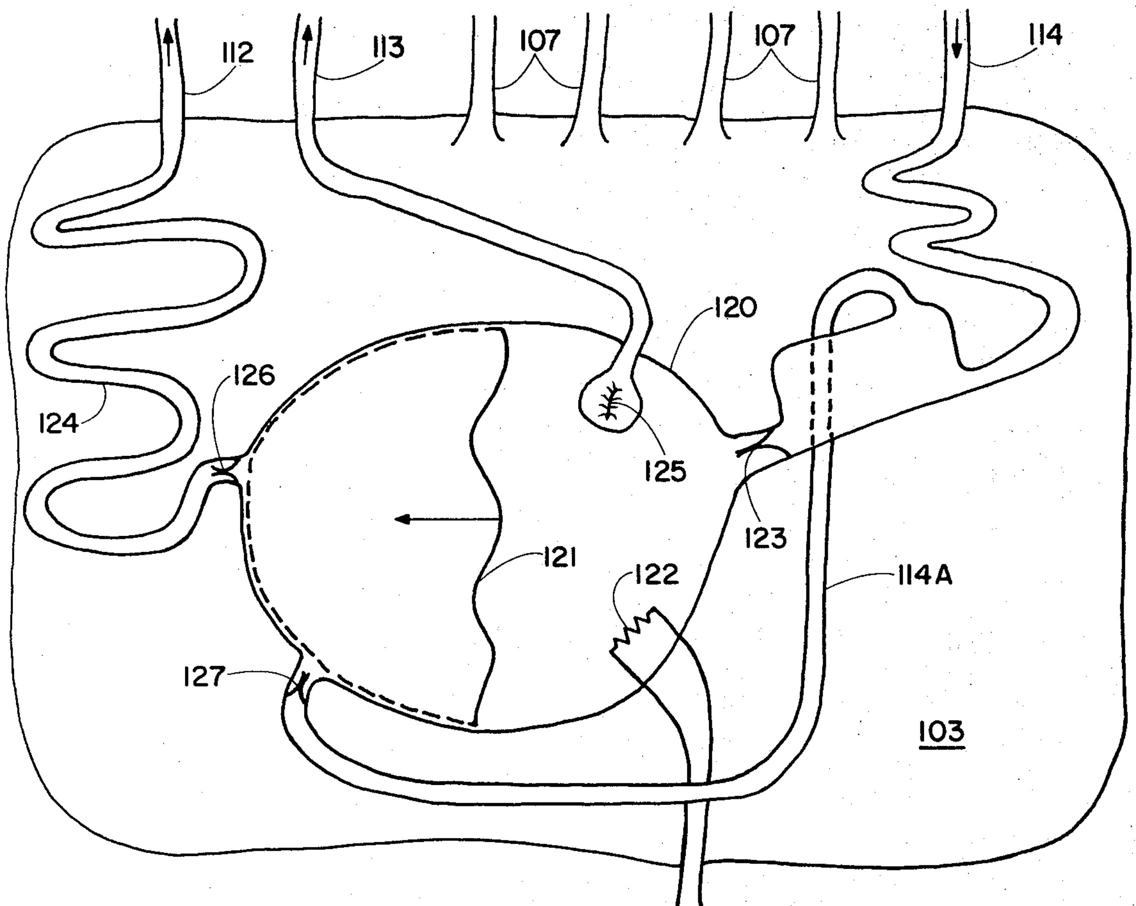
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Fig. 19

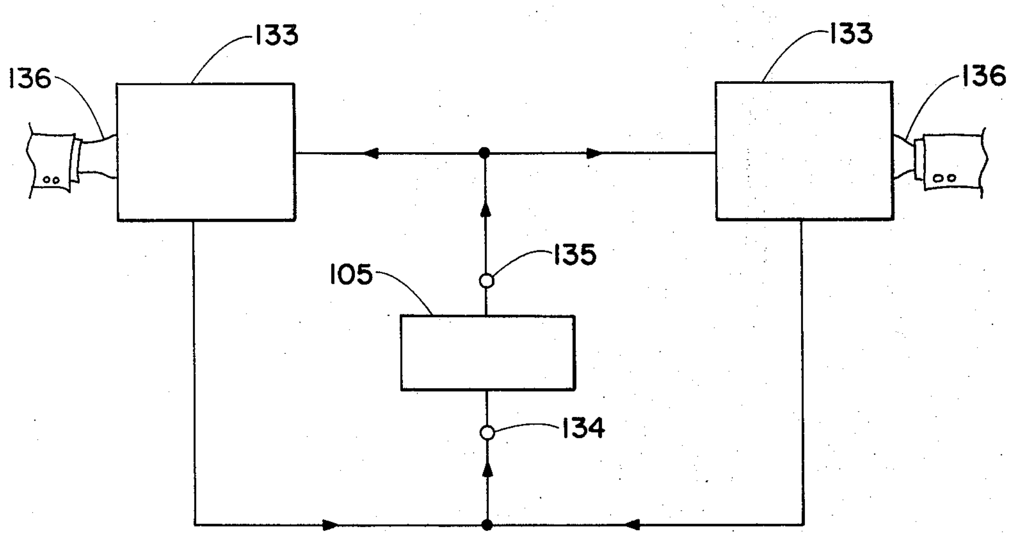
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Fig. 20

SOFT CONTROL MATERIALS

This invention relates to a novel class of soft controlled structures which may be used to interact with a user as a medium of communication, as well as to perform controlling functions.

It is usual, when designing a medium of communication, to determine an objective, to choose materials, then to construct a structure to fulfill the objective. Normally the materials are hard, in the sense that a gear may be cast, a frame for a machine may be constructed to a definite shape, an electrical circuit may pass current through a hard wired circuit, etc.

One step removed from the hard structure is the programmed structure, involving computers, in which functions to be performed may be changed at will through programming. A large number of programs may be stored in the computer, giving the appearance of great versitility, but the operation of the computer is still limited by the programs stored, and their function in relation to the data fed to it. In this sense the programs, or software, are used to control hard materials.

A step removed from the programmed computers is the self organizing control system, which, in application to a computer-like control system, learns to provide output signals related to the success or failure of earlier output signals to bring the controlled system to a previously defined, or externally defined, set of objectives. The present invention is concerned with a self organized control system as applied to soft materials. The preferred embodiments involve decentralized control, as opposed to the more usually encountered central control.

It has been found that as the amount of information one wishes to transmit in a given time from one operating entity to another grows, the wider the transmission bandwidth required. For this reason, many modern control systems, such as computer communication systems, utilize some measure of local processing, after which only reduced amounts of information need be transmitted from one communicating entity to another.

We have found, however, that by providing completely localized control loops, a description of the information that need be communicated may be obtained by monitoring the operation of the loops themselves, rather than by monitoring the information processed by them. To give a simplistic analogy to a computer circuit, it is enough to know that a flip-flop in a ring counter has operated to deduce that a bit of information has been processed, and it is not necessary to know precisely what bits of information each segment of the counter has stored, at all times.

This invention is concerned not with monitoring the stimulae and information processed in each local unit, but with monitoring the response of the local unit to stimulae and its own information processing.

Thus it will be seen that in this invention a multiplicity of localized loops will be provided, interacting in an unprogrammed mode. Communication between localized units, and groups of units, will be at the level of sensing response, rather than of information processed.

Another factor involving the control structure of this invention relates to complexity of communication. Consider a scale of increased complexity of information transfer between persons, or between persons and machines: (a) the least complex or immediate; as in touching, between mother and child, or child and pet; (b) more complex, communal; as between two individuals pulling taffy, the hands-on or manipulative instruction; (c) still more complex, adjacent; as between two persons tuning a radio transmitter together; (d) still more complex, metaphorical; as between a computer operator and a light-pen graphic display, or a teacher drawing on a blackboard; (e) to the most complex, symbolic; including speech, computer programming, etc. Conventional control systems require interface and communication at the most complex of the above levels, which required, in correspondence, the most complex communication in terms of data to be transmitted to have a message sent and received.

The present invention provides for greatly reduced complexity of communication, since communication is provided at the least complex level of the aforementioned scale. This level is related to tactility. It will be seen that communication is obtained via pressure, texture, temperature, and movement.

In summary, this invention in its most complex form is directed to a communication system, as between units and a user, or units with each other, which has a large degree of localized control, and which transmits data from one unit to another or to a user, related to its own response to the information processed, rather than to the information itself; the system may be said to be both self-organizing and self-referent. While communication between units, or units and a user may be via electrical or electromagnetic interface, it is preferred but not limited to communication via heat, cooling, and/or application of pressure.

To construct this invention a new class of components has been invented, and as a group they will be referred to in this specification and Soft Control Materials (S.C.M.). It will be appreciated that each component may be used as a part of the system, or as a device with its own utility. To give an easier understood description of this invention, examples of many of the components will be described (additional ones becoming immediately obvious) followed by a system structure.

The basic structural units of S.C.M. are bags of gas, some sealed, some valved, some having holes or slits in their walls. Alternatively, foamed material having either open or closed cell construction may be used, the material chosen being dependent on its application. While the gas used may be air or nitrogen, it has been found that Freon provides advantages of particular utility, and hence is preferred. Freon may be made to boil at convenient temperatures such as room temperature and temperatures not far therefrom. Hence only a small amount of heat need be added or removed, or pressure applied or released from a given volume, and exceedingly large changes in volume in changing from liquid to gas or gas to liquid are observed. Similar external effects may be obtained by fluidic valving, using either well-known hard fluidic valves, or S.C.M. valves as will be described herebelow. The latter form of the invention is also within the spirit and scope, as described and defined.

A more detailed description of the invention will be given with reference to the drawings referred to below, in which:

FIG. 1 is a graph of vapor pressure of mixtures of two types of Freon gases at various temperatures;

FIG. 2 is a crossection of a piston pump according to one embodiment of this invention;

FIG. 2A is a portion of the crossection shown in FIG. 2, showing an alternative means for suppling heat;

FIG. 3 shows the crossection of the basic elements of a portion of a self-pumping pipeline;

FIG. 4 shows another embodiment of the invention shown in FIG.3, which is driven by the sun;

FIGS. 5A to 5E show the basic elements of various structural and textural components of S.C.M.;

FIGS. 6A TO 6E shows the crossection of the basic elements of a heat driven flip-flop component of S.C.M.;

FIGS. 7 and 8 show the crossection of two types of valves for use in S.C.M. systems;

FIG. 9,10, and 11 show the crossections of 3 types of valves for use in S.C.M. systems; FIG.

FIGS. 12A, 12B and 12C show in plan different stages in the operation of two types of torous valves;

FIGS. 13A and 13B show in crossection two examples of another form of valve;

FIG. 14 shows in crossection an example of a cusp valve;

FIGS. 15A and 15B shows an unique valve in the form of a Klein Bottle;

FIG. 16 shows how FIGS. 17 and 18 should be placed and viewed together;

FIGS. 17 and 18 together show in crossection a schematic of an example of a portion of an S.C.M. system;

FIG. 19 shows an enlargement of the gill portion of the S.C.M. system, and

FIG. 20 shows a schematic of a two way communication system using an S.C.M. system.

As noted above, the preferred gas to use within the gas bladders or bags is Freon, or more specifically, mixtures of different types of Freon. For instance, a mixture of 30% Freon 11 and 70% Freon 113 in liquid form, by weight, will provide a liquid which is stable to 98.5 degrees Farhenheight at 14.7 pounds per square inch absolute (normal air pressure at sea level) and will boil at higher temperatures, or lower pressures, or combinations thereof. It will be appreciated that the change from liquid to gas provides tremendous expansion volume ratios. A heater, selectively operated in a bag of liquid Freon of proper composition, can cause a quart sized bladder holding ½ ounce of Freon to inflate rigidly.

FIG. 1 is a graph of vapor pressure of Freon 11 – Freon 113 solutions at various temperatures. From this graph, a proper Freon solution for a specific application may be selected. It is believed that other graphs may be obtained from E.I. Dupont De Nemours & Co. Inc., Freon Products Division, Wilmington, Delaware, 19898. It is preferred that Freons similar to Dupont Freon No. 114B2 and No. 114 should be used, since their toxicity is low.

Since Freon is a superfluid, the bladders carrying it in both liquid and gas form must be sealed perfectly, as any pore will cause loss of virtually all the fluid. It has been found that bladders made of the material Capron, tradename of the aforementioned E.I. Dupont De Nemours have utility in this respect, as the material appears to hold Freon reliably. Some prototypes of the invention, however, were made of a laminate of Saran, Mylar, polyurethane and polyvinyl alcohol.

A simple motor as shown in FIG. 2 forms one type of component of the invention. The motor is comprised of a sealed bladder in the form of a bellows 1, within a cylinder 2 made of hard material. The cylinder 2 shown can have one end open, and the other end closed except for an annular opening 3. A heat conductive disc 4 of about the inner diameter of the cylinder 2 is placed therewithin, upon which the end of the bellows may bear. A small amount of Freon is held within the bellows, the amount dependent on the size of the bellows and the amount of desired expansion thereof.

It may be seen that as heat, shown by the arrows, is applied to the bottom of the cylinder, disc 4 conducts the heat to the bottom of the bellows, transferring it to the liquid Freon held inside. As the Freon is raised in temperature above its boiling point, it begins to change to its vapor phase, greatly expanding, causing the bellows to expand and extend within the cylinder 2.

As the heat is removed, the Freon will be caused to revert to its liquid phase, greatly contracting and pulling the bellows closed.

While the structure just described appears very simple, it forms a very useful component of S.C.M. systems. For instance the heat applied from the sun, the motor being used as a pump to raise levels of water, or do other useful work with diurnal or a multiple thereof periodicy. Alternatively, and more directly to the point of this invention, cylinder 2 may be a cylindrical gas bag which itself may be caused to expand or contract, narrowing or expanding the inside diameter wherein the bellows is caused to move. By selecting the inside diameter at will the inside volume is caused to change, and the bellows may be caused to expand to longer or shorter distances along the axis of the cylinder, presuming a predetermined amount of heat is applied thereto.

As a further alternative, two bellows may be placed head to head, so to speak, in a cylinder, containing the same, or different, boiling point Freons. By applying the same or differing amounts of heat to their ends, they can provide flip-flop or differential operations and the positions of their head junctions can be monitored as an output.

Singly or in the aforementioned combinations, movement of the bellows can provide either pressure on another component of the system or useful "hard" work by means of well known leverage systems.

An alternative method of supplying heat to the bellows is shown in FIG. 2A. Here a heating element, usefully electrical in structure, is disposed within the bellows at a location preferably where the Freon in the liquid phase is expected to pool. The wires will cause the heating element to heat up, locally boiling the Freon, causing the described expansion.

As an example, a coil of Nichrome resistance wire, having a resistance of 6 ohms per foot, made up of 1 foot of wire wound into a narrow helix 3 inches long, which was in turn wound into a ½ inch helix of approximately ⅜ inch diameter to which a voltage of 12 volts was applied, boiled 2 ounces of liquid Freon having a 75° F boiling point.

Another form of pump component according to this invention is shown in FIG. 3.

In FIG. 3, donut shaped bags 5 holding a small quantity of liquid of low boiling point, such as Freon are axially disposed about the inner periphery of a cylinder or bladder in the shape of pipe 6. It is preferred but not essential, that an inner linear 7 forms a flexible inner pipe within the holes of the donuts. The pipe-shaped bladder preferable is flexible, but not expandable.

Upon application of heat or pressure to the liquid in the cylindrical bags **5**, the bags are caused to expand inwardly, narrowing their holes, as the three shown as reference **5**A in FIG. **3**. The resulting reduced diameter of the inner liner **7** causes displacement of any fluid inside to either side of the narrowed portion.

It will be obvious that if the heat source is moved along the pipe, in a cyclical and sequential manner, fluid inside the inner liner will be impelled in a single direction.

Accordingly if, for instance, donut shaped bags labelled A,C,E,G, etc. were pulsed sequentially, as the fluid flowing past bag A is impelled to the right, once it passes through the hole central of bag C, the constriction of the inner walls of bag C will impel the fluid also to the right, at least to the degree required to overcome friction acting to stop the fluid flow. Similarly, bags E,G, etc will expand in sequence, further impelling the fluid to the right.

There is no special reason that only every second bag be caused in sequence. Once a pulse of fluid is past a particular bag, it may then be allowed to contract in order to expand again in proper time. While the already expanded bags are contracting, the alternate bags B,D,F,H, etc. also are caused to expand sequentially and further aid the pumping action.

Of course, each single bag, or groups of bags may be caused to expand sequentially as required by the specific application.

When operated and pulsed properly as described above, the inner portion of the pipe appears to constrict as an organism in peristalsis, constrictions in the pipe passing down as in an intestine.

It will be obvious that the gas bags will also inflate under pressure controlled by a fluidic control system of well known design, as a sequence of ring counter elements.

However, the use of Freon as the fluid within the bags, with no external fluidic controls has particular utility. In one embodiment, a heater may be inserted within each gas bag to be inflated. The heaters can be controlled from an external electronic control system of conventional design.

In order to reduce the external control required with a view to approaching the principles of localized control discussed earlier in this specification, one heater may be inserted in a single donut having a predetermined boiling point Freon, an adjacent cylinder in one direction having a lower boiling point Freon; successive donuts in the same direction having successively lower boiling point Freons in order. When the first heater causes the first donut to expand, it will transfer heat to the second donut, as well as exert pressure. The small amount of heat transferred will cause some of the Freon in the second donut to expand, ballooning it. This sequence will carry on to each successive bag, each expansion triggering the next in a self-propagating wave to the lowest boiling point Freon bag. At this point, the heat pulse to the first bag must be repeated.

The above-described self-pumping pipeline may be used in certain types of hostile environments without external maintenance. One typical environment is a desert in which the prime power available is the heat from the sun. In this environment, the necessary pumping action may be very slow as compared with conventional pumps, since one pulse may be in time cycle with the sun. Such a system is shown in FIG. **4**.

The pipeline is constructed similar to that of FIG. **3**, except that the outer pipe **6** should be constructed of a flexible membrane. The purpose of the flexible membrane is that when each of the bags **5** are expanded, they will form a bumpy surface along the bladder **6** caused by the bulges of each of the inflated donut shapes. Attached to each of the segments is a stiff erectile flap **8** having an upper heat absorbing surface. Since each of the flaps **8** is attached to the pipe membrane at approximately the side of the cylindrical bags **5**, expansion of one of the bags such as the one labelled D will cause the flap **8** to move substantially from its rest position as shown, since it lies at the side of the inflated, bulging, donut shape. With none of the bags expanded, the heat absorbing surfaces **8** will lie approximately flat upon the surface of the pipe **6**.

Each successive bag is filled respectively with low, medium, and high boiling point Freon; for instance 60 degree boiling point Freon in bag A, 80 degree boiling point Freon in bag B, and 100 degree point Freon in bag C (all temperatures Fahrenheit). Therefore bags A,D,G, etc contain 60 degree Freon, bags B,E, and H will contain 80 degree boiling point Freon, and bags C,F, and I will contain 100 degree Freon. Of course other arrangements and Freons having other values of boiling points may be used, as long as the lowest boiling point Freon can be expanded without disturbing the next.

As the desert sun rises over the pipeline, as the day progresses, first the most easterly 60 degree Freon is caused to boil. Therefore, the morning sun will be found to trigger bags A,D, and G into expansion. As the gas bags expand, the heat absorbing surfaces will rise, turning their dark faces away from the sun.

Once the heat absorbing surfaces have turned away from the sun, the bags will cool, contracting, and lowering the heat absorbing surfaces to the position eventually to an equilibrium position.

Since the sun does not stay in the same place, however, the cycle will be continuously repeated until the sun is in a position to heat the heat absorbing surfaces to the erected state even when the heat absorbing surfaces have risen. A highly directional flap face, such as a prismatic lens as used in a traffic stop-light, can be used to cause oscillation at multiple diurnal oscillation and pumping frequencies.

As an example, assume that when the sun is in its **10** o'clock position, the heat-absorbing surfaces attached to bags B,E, and H which hold 80 degree Freon will absorb enough heat to cause the movement as described above, the 60 degree Freon bags having already cycled to the equilibrium point and being fully expanded. Similarly, the noon sun will trigger the 100 degree boiling point bags C,F, and I into a cycling mode.

Since with a long pipeline many hundreds or thousands of miles long the sun will reach the most eastern end of the pipeline at an earlier stage than the most western, a slow pumping action as between segments of the entire pipeline will be found to occur. As the sun begins shining in the east, the most easterly gas bags holding the 60 degree boiling point Freon will begin to pulse, and as the sun travels westward, the 60 degree bags down the pipeline will provide a pumping action as described earlier.

As the sun rises in the east to a greater extent, the gas bags holding 80 degree Freon will begin a pulsing pumping action in a similar manner, as between themselves and their counterparts in a westerly direction down the pipe. Later the **100** degree boiling point Freon bags will function.

It will of course be realized that while the above described pipeline may be usefully employed in such locations as deserts, etc., tubes constructed similarly of millimeter diameter may be used to control fluids in communication systems, and of course the slow response time can be substantially altered. The heat supplied may not necessarily be provided from the sun, but may be warmth from parts of a human body, heat control pulses derived from peripheral soft control mechanisms, or heat given off from various hard machines such as adjacent motors, friction devices, etc. The pipeline pump may be used to constrict or to provide fluid flow as a logical element. Monitoring of the element may be provided by sensing which bag in a sequence is expanded, by obtaining a reflectivity index from the heat absorbing surfaces **8**, or by obtaining a surface texture reading; monitoring need not requuire measuring of the fluid flow itself.

It may be seen that the surfaces **8** need not be individually monitored in order to obtain information as to that is transpiring within the pipe. If the surfaces **8** carry reflective means on them, a reflectivity index may be calibrated and used to obtain velocity and volume of fluid flow. With the pipe pulsing and pumping at either a diurnal or higher rate, ripples of light will appear to be transmitted down the pipe. The frequency thereof may be used to control additional logical elements.

As an example, a pipe of capillary tube size can usefully be used to reflect or absorb heat from adjacent logical soft control materials. Alternatively, parts of the human body may be interfaced directly therewith (as the hand). A human can obtain a tactile indication of what is happening within the pipe. The eye can similarly gain an impression of what is happening within the pipe without resorting to a count of specific elements or frequency of movement.

The surfaces **8** can also be painted various colors, and color changes and textural changes may usefully be used as output indicators in monitoring activity of the pipe.

FIGS. **5**A and **5**B show more specific applications of the use of surfaces **8**.

In FIG. **5**A the ends of stiff surfaces **8** not attached to the bags of Freon are connected by second flexible flaps to another part of the surfaces of the bags **9**. This also illustrated in FIG. **5**B, which shows surfaces **8** connected to the junctions of individual bags **9**. The bags shown in FIG. **5**B are, of course, in their inflated mode.

By way of example, surface **8** is black and surface **8**A is reflective, for instance, painted with aluminum paint, silvered, etc. In FIG. **5**A, with the bags collapsed, the application of heat to the surfaces **8** will cause heat to be absorbed because the black surfaces face the source of heat. The heat source may be the sun, an electric heater, any radiant or conductive body, etc. which may be nearby or touching.

Once heat is absorbed, it is transmitted by reradiation or conduction to the bags full of Freon, causing the Freon to boil, inflating the bags. Since the surfaces **8** and **8**A are connected to opposite sides of the bags **9** as shown, once the bags are inflated, they will begin to erect into the position shown in FIG. **5**B.

A number of very useful applications result from this structure. Once the bags **9** are inflated, less of the black heat absorbing surface is exposed to the heat source, and since a proportion of the heat will be reflected by the reflecting surface **8**A, the amount of heat absorbed by the bags **9** will be regulated; the structure thus performs a regulating action.

Secondly, the texture of the surface changes from being virtually flat, with the surfaces folded as shown in FIG. **5**A, to a roughness as shown in FIG. **5**B. The structure can be fabricated into rolls of material fabricated with ribs of bladders containing small amounts of liquid Freon. Upon unrolling the material, the Freon may be allowed or caused to absorb heat, causing the bladders to expand and stretch, forming relatively firm ribs to a predefined structural shape. Accordingly, such structures as baby bottles and light furniture can be stored flat and in dispensing rolls, forming it's well known shape after unrolling and absorbing heat.

In addition, it will be seen that the thickness of the structure increases substantially, thus changing its insulating qualities. If a pair of conducting planes are attached across the peaks of the surfaces, the capacitance of the structure between the planes can change. Various additional applications can be made with the basic structure, from changing electrical conductivity by the increased dispersion of a carbon colloid which is disposed on the surfaces, to changes in color or design, having different surfaces painted as desired, and different structural strengths, flexibility, etc.

It may be seen that the above noted variations may be used to good advantage for controlling and monitoring purposes.

It will also become obvious that the size of the structure can vary from capillary size, for example, in which the gas bags are microcapsules, to the size of housing structures or larger. For instance, FIG. **5**C shows a self regulating housing structure in the form of a dome, which uses surfaces **8** and **8**A between a pair of transparent and flexible membranes **10** and **10**A. Heat, for instance from the sun, will be conducted by the surface **8** to the air inside the hollow of the structure, causing it to inflate through the "hothouse effect." With inflation, the surfaces **8** and **8**A expand to their triangular configuration, automatically regulating the amount of heat applied to the inside of the structure, as well as maintaining structural shape.

Of course, the spaces within the structure of the dome of FIG. **5**C can be filled with Freon, for faster and more positive inflation. The entire dome can also be made extremely small, for example ½ inch in diameter or smaller. Thus the structure can be used to obtain changes in texture, capacitance, electrical conductivity, color, etc. as described with reference to FIGS. **5**A and **5**B.

The structure of FIG. **5**D is similar to the one of FIG. **5**C except it is in flat configuration. Surfaces **8**, instead of being stiff, are flexible, while upper and lower planes **11** and **11**A are inflexible. Movement of plate **11** parallel to **11**A will cause more or less of the black or reflective surfaces **8** and **8**A to be exposed to a heat source. Accordingly, differential movement of plates **11** and **11**A can alter the point of equilibrium of the entire system.

Turning now to FIG. **5**E, a flat plate is shown on which is attached a multiplicity of the elements described with reference to FIGS. **5**A, **5**B, **5**C, and **5**D. For instance, element D is a device similar to FIG. **5**D; elements B are those similar to FIG. **5**B, and elements

C are small domes of the type described with reference to FIG. 5C. Elements F are small cylindrical pipes with air or Freon disposed within, which expand or contract with the amount of heat conducted to their interior.

The embodiment shown in FIG. 5E may be used for a variety of purposes. For instance, repeated in various configurations it can form a pleasing and changing wallpaper, which changes it's texture, reflectivity, color, etc., as heat or light is applied to various portions thereof. As used in a restaurant, for instance, body heat can be amplified and made to change the texture of the portion of the wall material next to a customer, for a pleasing effect. Changes in electrical conductivity, capacitance, reflectivity, etc., can be used to control useful external circuits which can interface another person or other control systems located nearby or connected thereto.

FIGS. **6**A to **6**E show schematically a soft control material oscillator or flip flop. A pair of flexible and resilient bags **12** and **13** are connected together through a narrow tube or opening **14** therebetween. The tube **14** allows pressurized gas to flow from bag **12** into bag **13**, or vice versa.

Within bag **12** a small quantity of Freon is held, in its liquid form, while bag **13** is empty. Liquid form Freon is symbolized as a rectangle within the bag, while gaseous Freon is shown as a circle.

Turning now to FIG. **6**B, it may be seen that a first pulse of heat (depicted by the arrows) is applied to the structure. The freon will boil, turning to a gas, expanding bag **12** until the gas is under considerable pressure. The gaseous Freon will begin to escape into bag **13** through tube **14.**

FIG. **6**C shows by the arrow the flow of gaseous Freon through the tube **14** into bag **13,** whereby bag **12** deflates. However, as the Freon gas flows through the valve into bag **13,** it suddenly expands, cooling it. In the stage of the cycle shown in FIG. **6**C a small amount of gas is left in bag **12** while the Freon which has entered bag **13** has condensed to a liquid. The bag **12** has contracted to a size just sufficient to maintain gas pressure through tube **14,** whereupon it ceases contraction. Therefore, it may be seen that bag **12** gas gone from a contracted stage in FIG. **6**A to an expanded stage in FIG. **6**B, and back to a mostly-contracted stage in FIG. **6**C.

A second pulse of heat is then applied to bag **13,** shown by the arrows in FIG. **6**D.

In FIG. **6**D the heat pulse has begun to heat up the liquid Freon in bag **13.** The Freon then boils, expanding bag **13** until the gas pressure is sufficient to force the Freon through tube **14** into bag **12.** At this stage, bag **13** is inflated while bag **12** is only inflated. As the gaseous Freon flows through tube **14,** it suddenly expands, causing it to liquify through condensation. This will also cause some of the remaining Freon in bag **12** to become cooled, helping to liquify part of it. Thus it may be seen that from a contracted stage in FIG. **6**C, bag **13** has expanded in FIG. **6**D, whereupon it is completely contracted in FIG. **6**E.

In FIG. **6**E and additional external heat pulse has caused the liquidified Freon in bag **12** to expand, forcing the now-gaseous Freon into bag **13** as shown in FIGS. **6**B and **6**C. The cycle will now continuously repeat itself as alternately applied pulses of heat are repetitively applied to each bag in succession. Accordingly, an expansion oscillator has been provided using the soft control material principles of this invention.

The heat pulses may also be applied in inverse, as pulses of cold, in a reciprical inverse structure. One method of applying a pulse of cold is by spraying the bag or bladder with liquid Freon which will quickly evaporate, drawing heat out of the bag. Alternatively hot gaseous Freon can be sprayed on the surface of a bag, and upon condensing, releases its heat to the condensed Freon within the bag, providing a heat pulse.

The resulting oscillation, vibration, or flip-flop action may be used to stimulate parts of the human body for communication or sensing purposes, may be used to apply pressure upon other tubes in order to constrict or change fluid flow wherethrough, or may be used a valves, ètc, within other tubes. Variations of the described systems may utilize different types of Freon within different chambers, allowing the construction of monostable or other types of flip-flops, three level logic devices, etc. The various chambers may be connected by elastomers or additional bags may be connected to the assembly in a now obvious manner to one skilled in the art understanding this invention, in order to produce ring counters, more complex vibratile devices, etc.

Other useful soft control devices are classes of valves, a number of which will now be described.

Turning now to FIG. **7**, a first valve is shown which comprises a first compressible fluid-carrying tube **16.** The arrow within the tube is intended to depict movement of a fluid therethrough. A capsule **17** of non-elastic material, houses an impermeable bag **18** filled with Freon chosen to be liquid at a preferred temperature. The temperature, of course, will be determined by the specifications of the system, and can be determined by one skilled in the art understanding this invention having a specific application. If the capsule **17** is impermeable, bag **18** may be deleted.

The tube **16** passes through two walls of the capsule **17,** and is sealed at the entry and exit points.

A heating means, which preferably is a heating wire of coil **19,** is disposed within the Freon, within the solid caplule **17.**

In operation, fluid flows through the first tube **16.** Upon application of an electric current to heating coil **19,** the Freon within the solid capsule or impermeable bag turns to a gas and begins exerting pressure on the walls of the first tube **16.** After enough pressure has been applied, the walls of the first tube **16** colllapse upon themselves, cutting off the flow of fliud therethrough.

It may therefore be seen that the application of electric current to the heating coil **19** will cause the device to act as a valve, cutting off fluid flow through the first tube **16.**

Alternatively, the solid tube **16** can be made of heat obsorbent or conductive material and be in physical, radiant, or convectional contact with an external source of heat. The presentation of heat to the body will cause the Freon to expand, cutting off fluid flow through the same mechanism as described above.

Turning now to FIG. **8,** an alternate type of valve is shown, which can operatue as a flip flop valve.

A first cylinder **20** of heat insulating resilient material is comprised of inner cylindrical wall **21** and outer cylindrical wall **22.** The space between the two walls is filled with Freon. The ends of the tubes **20** and **21** should be joined in order to form a container for the Freon.

A second cylinder or tube 23, usefully of about the same diameter as the tub e formed by inner wall 21, but not necessarily of that diameter, is disposed between inner and outer walls 21 and 22, emerging at the ends of the first cylinder 20. The ends of the walls 21 and22 are sealed around the second tube 23.

Freon fluid A, or indeed any fluid in liquid phase, is caused to flow through the first cylinder 20 within the tube formed by the inner wall 21. Freon fluid B is caused to flow through tube 23.

When fluid A is heated, the Freon encapsulated between walls 21 and 22 will begin to expand, eventually causing enough pressure between the walls to pinch tube 23, cutting off flow therethrough.

Alternatively fluid B, becoming hot, will cause expansion of the Freon between the walls 21 and 22, causing enough pressure to collapse the tube formed by wall 21.

When Freon fluid A is hot, it will exert considerable pressure, and therefore will counteract the pressure exerted by the Freon encapsulated between the walls 21 and 22, avoiding collapse of tube 21. In the second case, when Freon fluid B is hot, it will similarly exert enough pressure to avoid collapse of tube 23.

Accordingly, it may be seen that by flowing heated Freon through either pipes 23 or 20, a simple flip-flop is produced whereby the flow of fluid through one or another pipe may be cut off.

Turning now to FIG. 9, another extremely useful form of valve is shown. In this structure a large diameter tube 24 is joined to a smaller diameter tube 25 as shown to form a wide angled funnel, or a venturi.

A heating means, for instance an electric heating coil 26, is disposed within the large diameter tube 24 adjacent the opening into the small diameter tube 25.

Freon fluid A is caused to flow in the direction shown by the arrow from the large diameter tube 24 into the small diameter tube 25. With the application of heat, for instance by applying a current to the heating coil 26, Freon surrounding the coil is caused to boil, causing turbulence at the junction of the two tubes. The turbulence effectively closes the small diameter tube 25 to fluid flow, effecting valve action.

With this form of valve, shutting off efficiency of over 85 percent has been observed.

FIG. 9A shows an alternative form of this type of valve, in which the expanded portion of the pipe 24 exists only for a short length.

FIG. 10 shows the structure of a variation of the embodiment shown in FIG. 9. Here large diameter tube 24 and small diameter tube 25 are disposed coaxially within an encompassing pipe 27. However, in this embodiment, large diameter tube 24 has an expandable flute containing flaccid bladders 24A containing Freon, the former which, when expanded under the pressure of fluid in the pipe, reaches to the inner periphery of pipe 27. Fluid thus flows down pipe 25, pressing the flute against the inside of pipe 27.

With the application of current to heating coil 26, turbulence and boiling is produced, causing the shutting off of fluid flow down pipe 25, as described with respect to the embodiment of FIG. 9. Also, the bladders 24A in the flute become erect, pulling the flute away from pipe 27. The fluid is thus caused to flow down pipe 27, and its pressure causes the flute to close in on itself at the centre of the pipe. This structure can be used to redirect the flow of fluid from small diameter tube 25 down large diameter pipe 27. Once the heat is shut off, and the flute becomes flaccid, its own resiliency, coupled with abberations in the stream of fluid, will cause it to open against the walls of pipe 27, and redirect the flow down pipe 25 again.

FIG. 12A shows a donut 32 made of a resilient and elastomeric material such as rubber, molded plastic, or other like material. It is filled with Freon or another expandable gas.

FIG. 12B shows the donut or torus 32 in it's operated position as a choke valve. In this structure the outside periphery of the torus 32 is considerably less expandable material than the inner periphery adjacent the hole of the torus. It may thus be constructed of plastic about the outside of the torus, and of rubber membrane adjacent the inside.

In operation, with the torus 32 heated, the Freon inside will expand substantially, and since the outer periphery of the torus cannot expand, the torus is forced to expand inwardly, effectively closing the hole. Should a tube carrying fluid have passed through the hole of the torus, it obviously would have been pinched closed.

Turning now to FIG. 12C, torus 32 is shown containing Freon which utilize a nonexpandable or limited expandable material for its structure over the surface adjacent the torus aperture, an an expandable material around the remainder thereof.

Accordingly with heating of the Freon, or other expandable fluid contained therein, the outside periphery of the torus will be found to expand subltantially, while the hole remains constant in size.

The utility of an expanding torus may be applied to other complex structures. For instance, it may be used to pinch off a multiplicity of tubes passing between it and another surface. In addition, it may be used to effect movement, pressure, etc. both as a controlling means or as an output device.

Turning now to FIG. 13A, a tube 33 is shown which contains a blister 34 of resilient material attached to the inside wall thereof. Within the blister is disposed a small amount of Freon or other highly expandable fluid. A heating means 35 such as an electric heating coil is disposed within the blister in order to impart heat to the Freon.

With the application of heat from the heating means 35, the Freon will immediately boil, causing increased gas pressure within the blister 34, causing it to swell up and effectively block tube 33, cutting off any fluid flow which may exist therein.

Of course heating means 35 may be deleted, and simply the heat of fluid simply flowing through tube 33 may be used to cause blister 34 to swell.

As an example of an application of use, one,two, or a larger number of blisters may be disposed peripherally around the inside of tube 33. Tube 33 can be used to carry water, as in a bath supply. An appropriate temperature Freon such as one which boils at 103° F. may be used within the blisters. Should the water passing therethrough become hotter than 103° F.; the blisters will be caused to swell, effectively choking F., flow of hot water therethrough. Whould the temperature decrease, the blisters will contract, opening the passage to a larger flow. With a valve of this nature in a hot water pipe in addition to a pipe carrying cold water, both connected to a mixing chamber, and if desired a feedback tube carrying a sample of the mixed water back to the blister valve, automatic control of temperature of water flowing into a bath can be obtained.

Turning now to FIG. 13B, a variation of the embodiment shown in FIG. 13A is shown. Pipe 33 contains blister 34 as described earlier, but instead of a source of heat to inflate blister 34, a pair of tubes 36A and 36B communicate through the wall of tube 33 to the inside of blister 34.

A flow of fluid through tube 36A into blister 34, and out through tube 36B can provide the same inflation ability to blister 34 as in FIG. 13A. With considerable pressure of control fluid through tube 36A, blister 34 will be caused to inflate, blocking tube 33.

This pressure may be obtained by, for example attaching a torus valve 32 such as described with reference to FIG. 12B around tube 36B. Closure of valve 32 will stop release of pressure of the fluid flowing through tube 36A, causing blister 34 to expand and to block tube 33. Release of torus valve 32 releases the pressure in blister 34, allowing a free flow of fluid from tube 36A through tube 36B.

Of course other types of valves may be used instead of torus valve 32, such as additional soft control logic elements deep within a system. However, the example described above shows how the application of heat to, for example, torus valve 32 can cause closure of pipe 33.

Of course, tube 36B may be deleted if pressure of fluid to tube 36A is externally controlled through one pipe alone as will be readily apparent to one skilled in the art understanding this invention.

FIG. 14 shows the structure of a one way valve useful in soft control technology. Tube 37 contains within it a resilient, but directionally disposed cusp 38. Movement of fluid through the tube 37 will cause opening of the cusp 38, allowing fluid to traverse therethrough. However, fluid attempting to flow through tube 37 in the opposite direction will cause the sides of the cusp to close upon themselves with increasing pressure, whereby the valve is positively held closed.

The cusp can be constructed of resilient, but formed plastic in the shape of a horn, where the bell of the horn is fastened around the inside periphery of tube 37. Of course, the tube need not be of circular crossection; the horn need only configure to the inside shape of tube 37.

The narrow opening of the horn may be constructed of a pair of flaps, normally biased against each other. Alternatively, the lips of the horn may be formed of reed material or blisters of Freon or the like.

Turning now to FIG. 15A, a more complex form of valve is shown. The structure of this valve is basically a Klein Bottle, formed of a tube which has one end turned back upon itself through a wall thereof, joining the other end from the inside. The entrance through the wall of the tube through which the end is drawn is shown as aperture 39. The sides of the tube are sealed to the sides of the aperture.

As gas such as Freon enters the mouth of the Klein Bottle in the direction shown by the arrow, the stomach of the bottle begins to expand. Since the end of the stomach is sealed against the junction between the two ends of the tube, the gas cannot escape.

With enough gas pressure, the stomach expands to the point at which the neck of the tube at the aperture is pinched off. This is shown in FIG. 15B, wherein it is clear that stomach 40 is full of gas, the pressure thereof having pinched off the inlet. Accordingly, it cannot escape and the Klein Bottle remains full. This demonstrates the operation of a self-limiting pressure valve.

In order to utilize the valve in a simple way, tube 41 having resilient walls and carrying a fluid, is disposed next to the stomach 40 of he Klein Bottle. As the stomach expands, it exerts pressure on tube 41, collapsing its walls and blocking the flow of fluid. When the stomach is full and the inlet valve blocked, tube 41 will remain shut to fluid flow.

In order to allow release of the inlet valve, fluid outlet valve 42 is connected through the stomach 40 wall. This may take the form of a valve having narrow diameter which acts as a choke, releasing the pressure relatively slowly.

Accordingly, with gas pressure filling the stomach 40 at a higher rate than is released through outlet valve 42, stomach 40 will grow, and when the input gas pressure is off, as well as tube 41. Accordingly, the input of now pressurized gas will cease, but the outflow of gas through valve 42 will resiliently take it's previous form, allowing gas to pass through. When a further amount of gas has been released through the relief valve 42 from stomach 40, the valve at aperture 39 will open, allowing another pulse of input gas to expand stomach 40, and the cycle repeats itself.

One can see that with a cyclically reinforcing pulsating input source of gas under pressure, the Klein Bottle cyclically closes and opens, responsively causing tube 41 to block and pass fluid therethrough. Stomach 40 in holding a quantity of gas thus can act as a transmission delay device.

It is obvious that combinations of tubes and Klein Bottles may be provided to form sophisticated logical and lively structures which may be used for control purposes, sensory input and output devices, etc.

FIG. 16 shows the manner of arranging FIGS. 17, 18, 19, and 20.

FIG. 17, 18, 19, and 20 show a cross section of an embodiment of soft control material which forms the self-referent, self-organized structure first referred to in this specification, and uses components as described above.

The material is made up of four layers, (a) a top cutaneous layer 100 and a subcutaneous layer 101 underlying the cutaneous layer, (b) a muscle layer 102 underlying the subcutaneous layer, (c) a gill layer 103 underlying the muscle layer, and (d) an air storage layer 104, underlying the gill layer. A control layer may be imbedded within the air storage layer may be imbedded within the air storage layer or distributed within the other layers. The controllers 105 of the control layer are shown as electronic in structure, but of course fluidic or other types of control structures may be used.

Turning first to the cutaneous layer 100, this layer is about 3 inches in thickness, constructed of a tough, elastomeric, porous foam, permeable to air, and soft to the touch, such as polyeurethane foam.

Randomly distributed within the cutaneous layer are small nodules 106, constructed of Freon-impermeable material, having a small amount of Freon therein. The nodules are of such quantity as to expand and stretch when heated with the Freon boiling. It is preferred that the Freon used within the nodules boil at about 75 degrees Fahrenheit, so as to be marginally liquid stable at room temperature. The nodules should be nominally ¼ inch or smaller in diameter with the Freon in liquid phase, and expand to about ¾ inch in diameter when the nodule is swelled to a blister with the Freon vaporous. The nodules should be in quantity about 4 per cubic inch, when whrunk, and dispersed regularly within the foam material. The nodules can also usefully take the form of FIG. 5C earlier described.

It may be seen that as the hand of a person touches or strokes the surface of the cutaneous layer, his body warmth will cause the Freon in the nodules **106** to rise in temperature above normal room temperature (about 72°), and also above the boiling temperature of the Freon, causing the nodules to expand, in many cases expanding against each other. This causes the surface of the cutaneous layer **100** to rise where the body heat is retained, leaving a welt.

It may also be seen that the longer the hand (or other source of heat) rests on the cutaneous layer, the deeper the heat will flow therein, causing more of the nodules deeper in the material to expand and causing the surface of the material to rise to a greater extent. Since the polyeurethane foam is elastic, it will resiliently move with the expanding nodules. The firmer the hand is pressed into the material, the better the heat coupling will occur between the material and the hand, causing greater pressure back against the hand by the expanding nodules.

Further interspersed within the cutaneous layer are pore tubes **107** having outlets at the top surface of the material. The pore tubes extend directly through the cutaneous layer **100** and meander so that they may expand in length as the cutaneous layer **100** expands in thickness, and as welts and undulations are formed. The pore tubes **107** extend completely through the acutaneous layer. It is preferred that there should be about 15 pore tubes for 1 square inch of surface, having an inner diameter of typically 1/32 of an inch. The figures show a considerably smaller number of pore tubes and nodules, and the dimensions are distorted, for the sake of clarity in this specification.

At the upper neck of each of the pore tubes torus valves **108**, such as those described with reference to FIG. **12**, are disposed. These valves are of both types: type A being closed when warn and open when cool, and type B being closed when cool and open when warm. Accordingly, in a random manner when warmth is applied to the surface of the cutaneous layer **100**, some of the torus valves will be caused to close, cutting off air traversing the pore tubes **107** to the surface, while others will open. Thus approximate equilibrium is obtained. With the presence of a hand or other body on the surface, the pores will be closed through blockage.

In addition it will be seen that the gas or air flowing through pore tubes **107** can be of different temperatures. If cool air is traversing through the pore tubes, these will tend to cool the adjacent nodules, decreasing any welt appearing at the surface which may have been formed due to the passing of a hand over the surface. If warm air is passing through the pore tubes, it will tend to cause the adjacent nodules to expand, increasing the welt size at the surface, increasing the pressure on a hand or body pressing on the surface above the welt, which may have caused the welt in the first place.

It is preferred that those pore tubes having torus valves which are open when cool should be coupled to a source of cool air, and those having torus valves which are open when hot should be coupled to a source of warm or hot air.

In addition, at the surface of the cutaneous layer **100**, the surface may be caused to change in roughness, permeability, reflectivity or color in a manner described earlier in this specification. This will give additional response information to the body interfacing the surface of the cutaneous layer **100**.

Strips of electrically thermoresistive material **109** lie along the surface of the cutaneous layer, each about ⅛ inch in width, negligible thickness, and 1 inch long or longer, depending on the desired resolution of the desired response at a particular location on the surface. Of course they may also be of different shapes or sizes as well, depending on the desired response characteristics. With the dimensions described, they should be spaced approximately 3 per inch of surface length. The resistive strips may be made of colloidal carbon mixed in a fluid Freon base, within a plastic Freon impermeable housing, material which changes it's electrical characteristics with stretching or compression, or a well known thermistor selected for the specific application desired. In addition, instead of electrical thermoresistive material, light-sensitive resistors may be used, which can be interspersed between strips of thermoresistive material in order to make the surface light responsive. A well known type of photoresistor which is suitable is trademarked Raysistor, available from Raytheon Corporation. The material of the cutaneous layer itself is suitable, not cut into strips according to the desired application.

The aforementioned resistors will be coupled to the controlling means and to other components, in a manner to be discussed later in this specification.

Under and abutting the cutaneous layer **100** is the subcutaneous layer **101**, preferably about 1½ inches in thickness. The subcutaneous layer **101** is made of fibrous foam or similar material, minimally or not elastomeric, but expandable due to its fibrous quality.

Interspersed within the subcutaneous layer are larger nodules than those previously described, but of similar type, which are expandable to about 1 inch in diameter when activated. These collapsed nodules **110** contain a small amount of Freon 75° and take up very little space when the Freon is in its liquid phase. Nodules **110** give a much larger (in terms of displacement) response than nodules **106**, but since it takes a considerably larger amount of time for heat to penetrate to them, or to dissipate, they act with time delay with respect to nodules **106**. They should be placed within the subcutaneous layer at a frequency of about three for every 2 inches of surface area.

Also within the subcutaneous layer, pore tubes **107**, are joined to a fewer in number but larger pore tubes, so that a source of air may be more efficiently distributed throughout the material and within the individual pore tubes in the cutaneous layer **100**. The pore tubes within the subcutaneous layer are placed very close to the nodules **110** so as to be easily kinked by expansion and undulation of the subcutaneous layer, whereby the air traversing through the tubes may be cut off.

It may be seen that air flow through the pore tubes, when increased, requires that additional heat must be applied to the torus valves **108** in order to cause the tubes to be pinched closed. Heat from adjacent areas or layers may cause the torus valves **108** to close, but they will tend to close more readily if air flow to the surface through the pore tubes is obstructed, for example by the hand of a user being applied to the surface. The warmth and moisture of this hand, however, affects the conductivity of the surface and the thermoresistive material **109** causes additional electrical effects to be transmitted into deeper regions of the soft control material. In a manner to be described later, this affects the surface as well.

It is important to note that the cutaneous layer sections each alter the environment of adjacent sections, affecting the behaviour thereof, causing a spread of effect to adjacent regions of the cutaneous layer and other layers. The user is able to adjust his behaviour so as to obtain a behaviour of the surface which is of interest and predictability to him, but in doing so, he interacts with it in a manner determined by the total soft control material complex. The rich diversity of behaviours, and their spread, and their meaningfulness given to the user requires that each small region have a local structural control with self referent parameters to be described at length below.

In summary, it may be seen that the cutaneous layer **100** and the subcutaneous layer **101** are both affected by the flow of air through the pore tubes and through the foams, under pressure, around the Freon filled nodules. This air has been heated or cooled by underlying layers as will discussed below, in order to cause expansion of the nodules, and so form welts at the surface of the material. This may alter the color and texture of the surface, as will expansion of the nodules caused by stroking, touching, or pushing of the surface by the hand.

Underlying the subcutaneous layer, about 1½ inches thick, is the muscle layer **102.** The muscle layer is characterized by relatively large (about 3 inches in diameter when expanded) outer muscle sheathes enclosing a group (for instance of about seven per muscle) inner muscle sacs of about 1 inch in diameter. The sacs and sheathes are constructed of non-elastomeric, impermeable, flexible membranes within the inner muscle sacs 75° Freon is held.

The outer muscle wall is pierced by three tubes, 38° Freon entry tube **112,** 114° Freon entry tube **113,** and exhaust tube **114.** The entry port of entry tubes **112** and **113,** each have spray nozzles such that 38° Freon in liquid form may be sprayed over the surface of the inner muscle sacs **115,** and 114° Freon in gas form may be sprayed over inner muscle sacs **115.** The spent mixture of 114° and 38° Freons exit through exhaust tube **114.**

When completely expanded the muscle wall **116** will take up approximately 2 to 3 cubic inches due to the expansion of the inner muscle sacs. When all the Freon within the muscle is in liquid form, the entire muscle will be an almost two dimensional laminate of sheets due to the small amount of liquid Freon required and the small thicknesses of the walls of the muscle: of the order of a few mils in thickness. Accordingly, it may be seen that great expansion, and hence, undulation of the soft control material may be obtained by expansion of the muscle sheath.

Since the Freon within the inner muscle sacs is 75° Freon, boiling at slightly above ambient room temperature, additional amount of heat added over room temperature swells the muscle sac; additional cooling turns it to a nearly two dimensional sheet.

Within the 38° Freon entry tube is located Freon valve **117,** which is similar to the one described with reference to FIG. **9.** This valve controls the entry of 38° Freon passing through tube **112.** Consequently, with the inner muscle sacs **115** expanded, when 38° Freon is valved and sprayed onto the surface of the inner muscle sac, within the outer muscle sac, it rapidly turns to gas, taking up its heat of vaporization from the 75° Freon within the inner muscle sacs **115,** causing the 75° Freon to turn to liquid and collapsing the inner muscle sacs rapidly. 114°

Within the 114° Freon entry tube **113,** 114° Freon is valved utilizing constriction valve **118,** which is similar to the one described with reference to FIGS. 13A or 13B.

The 114° Freon in its hot, vapor form is pumped and valved through entry tube **113** and sprayed within the outer muscle sac **116** over the collapsed inner muscle sacs **115.** The 114° Freon is rapidly condensed by the temperature of the 75° Freon which takes on heat of vaporization from the condensing 114° Freon, rapidly swelling the inner muscle sacs.

The mixture of 38° Freon and 114° Freon in mixed gas and liquid form exit through exhaust tube **114.** Of course a multiplicity of exhaust tube exit ports may be placed around the muscle sac in order to accommodate different orientations of the soft control material and muscle layer.

Surrounding all the muscle sheaths is loose fibrous foam material. The outer muscle wall may be made of elastomeric material in order to forcibly collapse the inner muscle sacs when the Freon is cooled, in order to more rapidly condense and collapse it.

It may be seen, therefore, that the muscle layer performs two functions: rapid expansion and contraction, which causes movement from below the cutaneous and subcutaneous layers, and also rapid heating and cooling, which is transferred to the nodules in the overlying layers, causing them to expand or contract. In addition, the pore tubes **107** traverse through the muscle layer and may be pinched off by expansion thereof, decreasing the cooling transferred to the overlying layers and consequent enhancement of the warming and expansion of a particular volume thereof.

Over the region of exhaust tube **114** adjacent its aperture into muscle wall **116,** a conductive strip is wound, which increases its resistance with expansion, usefully imbedded in vinyl. Freon valve heating coil **117** (corresponding to element **26** in FIG. **9**), is connected through the resistive strip **119** to a source of current and to the controller. Accordingly, when the sheath **116** is fully swollen and expanded, the aperture of the exhaust tube **114** will be stretched, increasing the exhaust, which in turn stretches the conductive vinyl strip carrying electricity to the heater of Freon valve **117.** The strip, in expanding, increases its resistance, reducing electrical energy to the heater. Since the amount of current to the heater is reduced, the amount of boiling within the valve is reduced, increasing the amount of Freon 38° passing into the outer muscle sheath **116,** which increases the cooling thereof. Accordingly, the muscle undergoes contraction which increases the construction through exhaust tube **114,** causing a reduction in the amount of Freon by the same mechanism described earlier. Accordingly it may be seen that the muscle undergoes rhythmed expansion and contraction cycling, (assuming proper operation of the mechanism for pumping and separating the Freon into the muscle layer, and assuming a flow of air through the pore tubes and fibrous material which conducts heat away from the entire muscle).

The layer below the muscle layer is the gill layer. The purpose of the gill layer is to provide heat exchange for the Freon of the muscles, and also to provide a source of air to flow through the bore tubes **107.** FIG. **22** is an enlarged view of a gill segment.

Each of the gill segments are individual to the muscle units. Consequently the gill segments will be impermeable to air or Freon, except at certain apertures to be described below.

Apertures in the gill wall are: one for the exiting of 38° Freon, another for the exiting of 114° Freon, another for the inleting of the exhaust Freon from the muscle wall, and a multiplicity through which the pore tubes are connected.

Air is pumped through the gill, which is filled with porous resilient foam such as polyeurothane foam, and exits through the pore tubes. As the air within the gill is heated or cooled through heat exchange, the temperature of the air flowing through the pore tubes is changed accordingly, as described earlier, resulting in profound influence on the nodules **110** and **106** in the cutaneous layer. It is preferred that the gill layer is about 2 inches in thickness in its idle state.

Looking at the diagrams in conjunction with FIG. **19,** it may be seen that the heart of the gill layer segment is compressor **120,** which is divided down its middle by an impermeable flexible membrane **121.** On one side of the membrane within the compressor is a heating coil **122,** which has its heat controlled by an external controller.

The exhaust tube **114** is also connected to that side of the compressor **120**; within the termination thereof there being disposed a one-way valve **123,** which is similar to the valve of fFIG. **14.**

Also communicating with exhaust tube **114** is tube **114A** vertically disposed above a larger diameter storage length of the exhaust tube **114.**

It may be seen that as the liquid 114° Freon mixed with vaporous 38° Freon passes down the exhaust tube, the liquid Freon will flow along the bottom of the tube, through one way valve **123** into one side of the compressor **120.** The gaseous portion of the mixture, 38° Freon, will exit the tube **114A.** Tube **114A** is connected to the side of compressor **120** on the other side of membrane **121.**

An exit tube **113,** communicating with the side of the compressor which holds the 114° Freon, leads out of the gill and is connected to the muscle **116** as described earlier.

However, the Freon tube **112** is connected to the compressor **120** on the 38° Freon side of the membrane **121** through cooling tubes **124** which are disposed within the gill foam medium. Air traversing the foam past the cooling tubes cools the 38° Freon below its condensing temperature, allowing it to be valved via valve **117** as a liquid.

Freon entry tube **113** is connected to the compressor **120** via a stretch valve **125,** which simply consists of an elastically closed slit which opens when the compressor wall is under a predetermined amount of gas pressure. Accordingly, elastic membrane **121,** under compression, will stretch so as to push out the 38° Freon from its side of the compressor, wrapping itself over the entire inside surface side of the compressor **120** which held the 38° Freon.

It may be seen that 114° Freon enters via one way valve **123** to its side of the compressor **120.** An electric current is then caused to operate the heating coil **122,** which begins boiling the 114° Freon. In the meantime, the other side of the compressor **120** has filled with 38° Freon gas.

As the 114° Freon expands into gas, membrane **121** is pushed progressively along the inner wall of the compressor **120,** forcing the 38° Freon outwardly into cooling tubes **124,** through one way valve **126.** Exit of the 38° Freon gas back into tube **114A** is stopped by one way **127** disposed within the exhaust tube **114A.**

Once the pressure of the 114° Freon within the compressor **120** has increased to a predetermined point, stretch valve **125** opens, allowing the 114° Freon to escape through tube **113** into muscle **116,** drawing elastic membrane **121,** which brings in another portion of 38° Freon gas on the other side of the compressor **120.** At this point, heating coil **122** is caused to heat up again, again expanding the 114° Freon which enters through one way valve **123,** and the cycle is repeated.

Accordingly it may be seen that there may be obtained repetitive pulses of 38° and 114° Freons through tubes **112** and **113** into muscle wall **116,** causing alternate expansion and contraction thereof. This imparts an underlying throbbing, pulsing, and undulating to the entire structure. In addition, a movement of air is caused to flow through pore tubes **107,** which serves to cool the Freon through cooling tubes **124.**

While one type of cooling tube in a foam medium has been described, it is preferred that the cooling tubes be constructed of Freon-impermeable foam, which is completely interspersed but interconnected within air-permeable foam through which air may pass in large volumes; the Freon-permeable foam being isolated from the air permeable foam by an impermeable (to both air and Freon) membrane. It is accordingly preferred that the structure thereof be similar to that of human lung tissue, branches and leaves of a tree, or sea sponge, in elemental form it may be constructed of rods, pipes, or slabs of foam in a comb-like structure through which Freon may flow, sealed from, and surrounded by ordinary polyeurethane foam which has been poured and formed therearound.

Underlying the gill layer is air storage and pumping layer **104,** which, for instance, may be 2 inches in thickness. This layer provides a source of air, and folds the pumps which causes the air to flow through the foam of the upper layers.

The air storage layer basically consists of air sacs, sealed from each other, directly underlying each gill segment. The air sacs **128** communicate with the gill layers through one way valves leading to the gill layers, and to the ambient through one way valves leading to the air sacs **128.**

Within each of the air sacs are a quantity of air pumps **129,** which can usefully be of the form of simple motors, to the one shown in FIG. **2.** These air pumps may act either indepdently or in unison, and alternately contract and expand air bags **128** under control of the controlling means in order to pump air through the foam of the gill layers, and through the pore tubes **107.** The pumps **129** have been described adequately earlier in this specification and may be activated directly from electric heating coils therein, or may be connected through heat or moisture sensitive strips on the surface of the soft control material which modifies the amount of electricity transmitted to the pumps (not shown).

With the air pumps **129** operating in unison within air sacs **128,** it may be seen that they alternately compress and expand the air sacs. Upon expansion, one way valve **130** in the outside wall thereof is caused to open, and air is drawn in from the ambient into the air sac. One way valve **131,** communicating between air sac **128** and the gill **103** is forced closed. With the air pumps **129** operating in the opposite direction, i.e. drawing the air sac walls closer together, one way valve **131** opens and air from the air sac is forced into the gill. Since each gill is surrounded by an impermeable membrane, with the exception of the aforementioned pore tubes, etc., subsequent cycling of the air pumps continuously pumps fresh air into the gills from the air sacs.

The pumps may operate in unison with those in the other air sacs, or in an undulating fashion whereby the entire soft control material receives air passing therethrough in an undulating, cyclical or noncyclical and nonlinear form. As will be seen below, air pumps **129** are operated responsively to what is happening in the section of the soft control matrial immediately thereabove, and also with respect to its adjacent areas.

For a gill of the dimensions shown, that is, approximately two inches to a side, it is preferred to utilise a pair of air pumps in order to provide an air flow into the gill **103** of about 5 cubic feet per minute. Accordingly, enough one way valves are required to be used in the outside surface of the air bags, as well as between the air bags and gill layer as may allow the aforementioned amount of air to pass. We have found that three sets of valves per surface, having an annulus of diameter ½ inch is suitable.

We have thus far described a layered structure which is responsive to pressure, heat, cold, etc. Control has been manifest by an external application of the heat, cold, and pressure, as well as internal transfer thereof from an adjacent region. Internal control has been described basically as responsive to controlled valves, which, for the sake of this discussion, have been reduced to simple heating coils, sometimes effected by resistance changes in an adjacent, or remote regions of the material. The heater inputs therefore constitute a suitable place at which controllers may input.

In addition, on each nodule of the subcutaneous layer, on each torus valve at the neck of each port tube, on the surface of each muscle **116**, there is placed a resistive strip **132** which reacts to expansion. This may be the previously described vinyl strip having resistive material imbedded therein, or may be a painted resistive layer.

The resistive strips **132,** upon expansion, increase in resistance, providing an indication of the degree expansion of the ajacent layer. In addition, resistive strips **109** and similar ones placed throughout the cutaneous and subcutaneous layers in a regular order may be used with resistive strips **132,** to provide response information of the condition of the soft control material at those specific locations. Accordingly, we have defined control input terminals, and response terminals to the soft control material.

The self-organizing control system of U.S. Pat. No. 3,460,096 to R.L. Barron, issued Aug. 5, 1969, sold by Adaptronics Inc., of McLean Virginia is preferred to be used as the control **105** in this invention. This system obtains information regarding the performance of a section of the soft control material, including peripheral regions, predicts what must be done to enhance the trend of the function, and provides output control signals in order to operate individual components in order to enhance that trend.

Due to the complexity of the aforementioned Barron patent, we will not elaborate here on its structure. Suffice to say that the multiple input embodiment of the patent described with reference to FIG. **15** therein should be used, it having a multiplicity of command inputs and control signal outputs.

The resistors of the aforementioned resistive strips, responsive to moisture, pressure, and temperature, are used in bridge circuits (not shown), the outputs of which are connected directly to the command input terminals of the self-organized control system reference **133** in the Barron patent. Output commands are connected to amplifier circuits which control electric current to the heater elements (the electronic circuits being well known to anyone skilled in the art, and hence are not shown).

The control system **105** should have as many input terminals as there are sensing elements within a vertical cylinder (not necessarily round in section) through the soft control material above a gill. Similarly, there should be as many output terminals as there are response receiving heaters within the material within the same section.

However, it is additionally desireable to increase the number of input and output terminals by two-thirds so as to receive information from adjacent vertical cylinders. One third of the input terminals should be connected to one third of the response terminals of one adjacent vertical cylinder, and the other third of the input terminals should be connected to one third of the response terminals in another adjacent vertical cylinder. The aforementioned adjacent vertical cylinder preferentially is coaxial with the first cylinder, and the density of interconnection should increase closer to the internal vertical cylinder.

A vertical cylinder standing next to the first should also have a separate controller, with its input and output terminals connected in a manner similar to the first. The coaxial peripheral cylinder will thus overlap the cylinder controlled by the first controller.

It will be noted that Barron has encapsulated his complete conditioning logic stage in a module approximately 3 inches high, 3 inches wide, and 4 inches deep, using discrete components. Since there are a multiplicity of logic stages and units in Barron, it will be seen that the entire system takes up a large volume, compared to the thickness of the thickness of the soft control materials. It is therefore preferred that the entire Barron self organizing control system be manufactured using large scale integration on a single semiconductor slice, many slices having of the order of 6,000 active devices per chip being available today. Accordingly, it is preferred that the entire controller **105** should be housed either within the air bag **128** below the figurative cylinder which each control, or alternatively and preferably, individual controllers should be scattered throughout the entire soft control material in a way which is most efficient from a connection standpoint. However, air bag **128** is a particularly usefull location, since it provides automatic cooling of the semiconductor controller.

In operation, it will be seen that in the idle state, there will exist regular pulsing of the muscle sheath and random rippling of the surface of the entire soft control material (specifically manifested at the surface of the cutaneous layer). As variations in temperature, such as when a breeze crosses the room containing the material is exerted on the material, the rippling will take on a particular type characteristic, and welts, possibly in the form of waves, will appear on the surface of the soft control material. However, this rippling will be random and of little consequence unless an external stimulus remains.

Assuming now pressure of a user's hand on the surface of the material, certain of the pores **107** will become closed, and moisture and heat will be transmitted to the cutaneous layer, and to the subcutaneous layer after a period of time. With continued pressure of the hand, certain of the pore tubes will be distended, and certain of the pore tubes kinked and blocked at positions remote from the placement of the hand.

With the heat and blockage of the pores (blocking localized cooling of the nodules **106** and **110**), the cutaneous and subcutaneous layers will swell under the hand, causing a welt in the surface of the material to appear. In addition, with heat transmitted to the material, with blockage of the cooling air which traverses the pore tubes through the cutaneous and subcutaneous layers, the amount of cooling and heating balance with respect to the muscle lying below and adjacent will be changed, causing the cycle to be biased into a constant swelling or constant collapsing thereof, depending on its location. Cycling may be enhanced to greater amplitudes in remote locations due to the imbalance of the heating and cooling, and the unstable nature of each segment. The details of the operation of the muscle have already been described.

Information as to the state of distension of the nodules **110**, as well as pressure, heat, and moisture is also sent to the controller **105**. Since the controller is basically an averaging and consensus enhancement machine, its output signals will also activate the appropriate valves within its sphere of influence in order to further enhance the pressure exerted back to the hand exerting the initial pressure. In addition, it senses what is happening peripherally to the hand, and acts to enhance the differential.

Should the hand not simply exert pressure at one position, but exert a stroke over the surface, the entire mechanism will act to raise a welt over the place where the hand has been, until the heat is dissipated therefrom. Indeed, depending on the stability, i.e. the localized temperatures and states of adjacent regions of the material from where the hand is stroking, the controller may anticipate the position toward which the hand is moving, and raise a welt in anticipation of the hand moving there.

Again, depending on the condition of the peripheral regions to what has just transpired at a particular region, oscillating ripples may be sent out in the surface of the material from the position of the hand in unexpected directions.

A certain amount of time after which a user coacts with the material, he learsn the general characteristics of the material, and can communicate with it in a tactile mode. Earlier in this specification it was described that the tactile mode is one of the lowest orders of information transfer which utilises the smallest amount of bandwidth in order to transmit and receive a large amount of information. It is this goal which the above-described structure has thus achieved.

Because each controller **105** only controls a localized section of the soft control material, it may be seen that the material is entirely self referent, and self organizing.

We have thus described the soft control material with regard to interaction of the material with a single user. However, two or more users may communicate in a tacile manner using this invention.

Turning to FIG. **20** shown is a pair of transmit-receive terminals **133** which are lined with the above-described soft control materials. For the sake of this description, controller **105** is shown external to the terminals. The controller **105** is comprised of response input terminals **134** and control output terminals **135.** Accordingly, a user may insert his hand **136** into the terminal **133** and interact with the soft control material as described earlier. However, a second terminal is connected exactly in parallel with the first terminal, utilizing the same controller **105.** This structure is called "Telegrasp."

Accordingly, it will be seen that with the first user exerting pressure on the soft control material in his terminal, responses and control signals will be transmitted from controller **105** to that terminal for control thereof. However, identical responses will be provided to the other terminal **133,** and a user who has his hand within the latter terminal will be able to feel the response.

Similarly, in a real time and interactive mode, the hand **136** within the second terminal transmits tactile information to the hand in the first terminal.

Of course, the signals transmitted to and from controller **105** may be multiplexed and transmitted over telephone lines, radio links, and the like. Tactile information may thus be transmitted electrically, and studies indicate that the amount of information required to be transmitted is sustantially less than that which would be required for sensing and control of a high resolution three dimensional array of points within each of the terminals **133.**

The soft control material may be applied to a large multiplicity of applications. For instance, the seat used by an aircraft controller may be lined with the material; input information to the controller may arrive from the scanned radar screen. Airplanes arriving on schedule and in a controlled manner will provide a regular known tactile pattern to the aircraft controller, while airplanes deviating therefrom, and therefore which require special attention, will provide an early indication to the controller that he must become alert to the deviations. The unusual behavior of the deviate airplanes will be found to provide an unusual lump or series of ripples to the aircraft around controller, since it causes a tactile pattern which feels unusual.

Other applications of the soft control material are as mattresses (a sophisticated improvement to the water bed) lounge chairs, toys, etc.

While a specific structure of the invention has been described, it will become immediately obvious that, for instance, the torus valves, one way valves, nodules, etc. may be replaced or enhanced by the addition of other types of valves, pumps, tubes, etc. described earlier in this specification. The The larger the variety, and the larger the quantity thereof in a given space (reduction of size assumed) the richer will be the resolution of the tactile experience given to a user. For instance, the pore tubes **107** may be tube **16** described with reference to FIG. **7,** which may be pinched off by the use of a heater **19.** In addition, the valves of FIG. **8,** FIG. **15,** etc. may be used as the soft control material designer wishes. The invention is therefore limited only by the scope of the claims attached hereto, since variations of the invention therewithin will become immediately apparent to one skilled in the art.

What is claimed is:

1. A soft control structure comprising:

a. a multiplicity of bladders disposed adjacent each other in a three dimensional array,

b. a multiplicity of tubes passing through the array for carrying cooling or warming fluid for the bladders,

c. a compressible, porpous medium surrounding and supporting the bladders and the tubes in position,

d. low boiling point fluid contained within each of the bladders,

e. pressure sensing, heat sensing, and heating means interspersed among the (a), (b), and (c) elements

f. self organizing control means having a multiplicity of command input ports and control signal output ports, a predetermined number of command input ports connected to said sensing elements within a predetermined volume of said array extending through the array to one surface thereof, the remaining command input ports being connected to said sensing elements disposed in a second volume of said structure coaxial with the first volume, decreasing in connection frequency radially outward from the centre of the surface of said predetermined volume; a predetermined number of control signal output ports being connected to said heating elements in said predetermined volume of said array extending through the array to the surface, the remaining control output ports being connected to said heating elements disposed in the second volume of said array, decreasing in connection frequency radially outward from said predetermined volume.

2. A soft control structure as defined in claim **1,** in which the elements are arranged with the smallest bladders in a surface cutaneous layer, and larger bladders in a subcutaneous layer disposed under the cutaneous layer, each of the bladders containing a predetermined amount of low boiling point fluid.

3. A structure as defined in claim **2,** in which the compressible porous medium in the cutaneous layer is comprised of elastic, porous foam material, and the compressible porous material in the subcutaneous layer is comprised of loose, fibrous, generally nonelastic foam material.

4. A structure as defined in claim **3,** in which said tubes extend through both the cutaneous and subcutaneous layers to the surface of the cutaneous layer, branching into a larger number of tubes in the cutaneous layer than in the subcutaneous layer, and further comprising means for pumping air through the tubes to the surface of the cutaneous layer.

5. A structure as defined in claim **4,** further comprising a muscle layer disposed under the subcutaneous layer, having predetermined numbers of muscle means, each of said numbers being disposed under said predetermined volume, adapted to expand against and pulse the subcutaneous layer within said predetermined volume; a gill layer disposed under the muscle layer adapted to supply air to said tubes and to cool the muscle means; pump means adapted to pump air through the gill layer connected to the gill layer; and a compressible porous material disposed between the muscle means, and filling the gill layer.

6. A structure as defined in claim **5,** in which the pressure and heat sensing and heating elements are disposed adjacent and on the surface of predetermined numbers of bladders and tubes, and on the surface of the cutaneous layer in a regular array.

7. A soft control structure as defined in claim **6,** in which the low boiling point fluid is comprised of Freon.

8. A soft control structure as defined in claim **1,** further comprising a second structure isolated from the first comprising:

a. a second multiplicity of bladders arranged in a second three dimensional array,

b. a second multiplicity of tubes passing through the array for carrying cooling or warming fluid,

c. a compressible porous medium surrounding the bladders and the tubes,

d. low boiling point fluid contained within the bladders,

e. pressure sensing temperature sensing, and heating means interspersed among the latter (a), (b), and (c) elements,

f. the predetermined and remaining numbers of command inputs being connected in parallel to the sensing elements in the predetermined and second volumes of the first structure and respective similar predetermined and second volumes of the second array in a similar manner, and the predetermined and remaining numbers of control signal outputs being connected in parallel to the heating elements disposed in said predetermined and second volumes of the first and respective similar predetermined and second volumes of the second structure, in a similar manner.

9. A soft control structure as defined in claim **8,** further including rigid structural support means disposed against and holding the surface of said structure opposite the cutaneous layer, whereby a person may be supported upon the surface of the cutaneous layer, heat and pressure from his body being applied and blocking air flow on the surface of the structure, thereby interacting with the structure.

10. A soft control structure comprising:

a. a pair of housings

b. a multiplicity of bladders containing an expandable fluid, less than ½ inch in diameter when expanded, generally filling each of the housings,

c. a multiplicity of heat and pressure sensing elements regularly disposed among and on the surface of the bladders,

d. a self organizing control means having a multiplicity of command input and control signal output ports, having its command input ports connected to individual heat and pressure sensing elements in parallel with corresponding ones of said elements in each of the housings,

e. means connected to the control signal output ports for causing expansion of said bladders as determined by said control means in parallel duplication in each of said housings.

11. A soft control structure as defined in claim **10,** in which the expandable fluid is comprised of Freon, and in which the (e) means is comprised of heating elements disposed among said bladders in parallel correspondence in each of said housings.

12. A soft control structure comprising:

a. a first bladder,

b. a second flexible-walled bladder disposed contiguous with the first bladder,

c. low boiling point fluid held within the first and second bladders,

d. means for applying heat or cold to the fluid, whereby the fluid above its boiling point will be caused to condense and the fluid below its boiling point will be caused to boil, the first and second bladders thus individually contracting or expanding and acting against each other, and

e. means for sensing the combined surface change of both said bladders.

13. A soft control structure as defined in claim 12 in which the low boiling point fluid is comprised of Freon.

14. A soft control structure as defined in claim 13, further including a flexible pipe-shaped and inexpandable member, a multiplicity of alternating donut shaped second bladders coaxially and contiguously disposed inside said pipe-shaped member, each of said bladders containing predetermined amounts of low boiling point fluid; a carrier fluid contained within the inner regions of said pipe-shaped member within the donut holes of said bladders, and means for applying heat to limited lengths of said pipe-shaped member for transmission to the low boiling point fluid, whereby the underlying bladders are caused to expand and constrict inwardly, forcing the carrier fluid to flow away from the constricted region.

15. A soft control structure as defined in claim 14, in which the pipe-shaped member is comprised of flexible material adapted to form coaxial bulges when said bladders are expanded; further including erectile flaps having one edge of each attached to said pipe-shaped member along a line on it's periphery to one side of the peak of the bulges, said flaps being adapted to erect when the second bladders are inflated, and to lie flat upon the surface of the pipe-shaped member when the second bladders are not inflated.

16. A soft control structure as defined in claim 15, in which the flaps are disposed on the surface of the pipe shaped member facing the means for applying heat or cold; the outer surface of the flaps having an upper surface of heat absorbing material, and an under surface of heat reflecting material.

17. A soft control structure as defined in claim 12, in which the first and second bladders and additional numbers thereof are in the form of closed tubes connected so as to form a sheet of tubes, the sheet being storable in a flat, folded or rolled configuration, which upon being raised in temperature, is adapted to erect into a self supporting structure predetermined in shape by the physical relationship and location of said bladders.

18. A soft control structure as defined in claim 12, in which the first and second bladders are in the form of closed tubes connected in parallel along their respective edges so as to form a sheet of tubes, further including a first erectile group of flaps having one of each of their edges connected to the tubes along similarly facing sides of the tubes adjacent the line of connection between each of the tubes, and a second group of flaps connected along one of their edges to the tubes adjacent the line of connection between the tubes, and connected along the other edges to the other edges of the first group of flaps, the second set of flaps being apapted to stretch taut upon erection of the first group of flaps by inflation of the second bladder, and fold under the first group of flaps upon recumbence thereof, the first or second group of flaps having an outer surface of heat absorbing material, and the remaining second or first group of flaps having an outer surface of heat reflecting material.

19. A soft control structure as defined in claim 18, in which the surface of the tubes opposite the sides covered by the first and second flaps forms a continuous membrane, and further including means for interconnecting the junctions between the flaps so as to define a predetermined plane area supported by the flaps in their erected mode, the predetermined plane being larger in area than the area of the continuous membrane, such that when the flaps are in their erected mode, the entire second bladder structure forms a bowed shape due to the differential bending thereof.

20. A soft control structure as defined in claim 12 further including a narrow opening between the first and second bladders of predetermined size such as to allow passage of the fluid in its gaseous phase at a predetermined rate, the (d) means comprising means for heat or cold pulsing each said bladder in sequence.

21. A soft control structure as defined in claim 12, in which the second bladder is of the form of a fluid-carrying compressible tube passing through two walls of the first bladder, the walls of the first bladder being comprised of non-elastic material.

22. A soft control structure as defined in claim 21, further including fluid heating means disposed within the first bladder.

23. A soft control structure as defined in claim 12, in which the first bladder is of the form of a thick hollow-walled cylinder, comprised of an inner cylindrical wall joined and sealed at its ends to an outer cylindrical wall, and in which the second bladder is in the form of a narrow fluid-carrying tube passing through the sealed ends of said cylinder between the inner and outer walls, whereby fluid at one temperature can pass through said cylinder within the inner cylindrical wall, and fluid at another temperature through said tube.

24. A soft control structure as defined in claim 12, in which the first bladder is in the form of a tube, and the second bladder is in the form of a Klein Bottle disposed contiguous with the tube, further comprising means for applying fluid pressure to the mouth of the Klein Bottle.

25. A structure as defined in claim 24, further including a fluid outlet valve connected through the wall of the larger diameter section of the Klein Bottle.

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