**MEDICAL SPLINT APPARATUS**

Inventors: Anatoly Ivanovich Artemenko, ulitsa Levitskogo, 5, kv. 8; Rafail Yakovlevich Gershtenkern, ulitsa Artema, 163, kv. 28; Igor Nikolaevich Yagupov, ulitsa Levitskogo, 7, kv. 1, all of Donetsk, U.S.S.R.

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References Cited

UNITED STATES PATENTS

2,726,658 12/1955 Chesney, 128/400
2,260,134 10/1941 Ballman, 128/400
2,749,914 6/1956 Braley, 128/402
3,464,228 8/1969 Hitchcock, 165/74 X
261,824 1/1982 Benner, 165/73

1,078,207 11/1913 Michael, 165/46

OTHER PUBLICATIONS

“Anesthesia by Local Refrigeration,” Restarski The Journal of the American Dental Assoc. May, 1944 pp. 600, 601

Primary Examiner—Richard A. Gaudet
Assistant Examiner—J. Yasko
Attorney—Holman & Stern

ABSTRACT

A medical splint apparatus, useful for treatment of crush syndromes, an inflatable splint body adapted to be inflated by a working fluid received thereinside, and a heat exchange structure including an external vessel and an internal vessel received inside the external vessel, the vessels communicating with each other and being provided with respective fluid pressure control valves, the vessels also communicating with the inflatable splint body, the external vessel being filled with a supply of the working fluid and the internal vessel being filled with a supply of a cooling agent, particularly solid carbonic acid.

5 Claims, 4 Drawing Figures
MEDICAL SPLINT APPARATUS

The present invention relates to splint apparatus for rendering medical aid, and, more particularly, it relates to apparatus used for treating crush syndromes.

Medical splints are known, which comprise an inflatable body made from an elastic material, adapted to be filled with either liquid or gas and incorporating means for securing this body to and tightening it about an injured part of a human body (see, for example, British Pat. No. 970,890, Class A5R). Splints of this known kind effect immobilization and compression of a limb or other part of a human body.

However, these known splints do not provide for effecting immobilization and compression of an injured limb simultaneously with controllable cooling and controllable compression thereof.

It is an object of the present invention to eliminate this shortcoming of the known splints.

The present invention has for its aim the provision of a medical splint apparatus, which is capable of effecting simultaneously immobilization, controllable compression, and controllable cooling of an injured part or parts of a human body, particularly of an injured limb.

This aim is attained in a medical splint apparatus comprising a heat exchange structure including two vessels one of them being received inside the other and being in communication through a throttling orifice, the internal vessel of said heat exchange structure being provided with an opening and being filled with solid carbonic acid CO₂, and also being provided with a conduit for escape of compressed gas produced by sublimation of solid carbonic acid, the external vessel being provided with inlet and outlet openings for working fluid contained therein; due to the heat exchange between solid carbonic acid and working fluid solid carbonic acid sublimes producing gas, a portion of said gas escaping through said throttling orifice from the internal vessel into the external vessel, producing pressure therein, said heat exchange structure being in communication with the inflatable splint body preferably by means of flexible conduits.

In order to provide for varying pressure of gas produced by sublimation of solid carbonic acid in the internal vessel of the heat exchange structure, the internal vessel of the heat exchange structure is provided with a valve, and in order to provide for immobilization and to ensure a given pressure inside the inflatable splint body, the external vessel of the heat exchange structure is also provided with a valve.

In order to provide for controllable compression and cooling of specified portions of a human body, it is advisable for the internal and external walls of the inflatable splint body to be made from materials featuring different degrees of rigidity, the internal and external walls being interconnected by seams in such a manner as to form therebetween a zigzag a tortuous fluid passage communicable with the heat exchange structure.

In order to provide for selective insulation of specified portions of a human body from cooling, the internal wall of the inflatable splint body can be associated with a set of selectively removable panels made from a thermally insulating material, e.g., from a porous plastic material.

In order to provide for accelerated cooling of injured parts of a human body, there is a diaphragm-type pneumatic pump between the heat exchange structure and the inflatable splint body driven by compressed gas produced by sublimation of solid carbonic acid.

As compared with the known splint structures, the herein disclosed medical splint apparatus features an advantage of combining immobilization of an injured portion of a human body with controllable selective compression and controllable cooling of such portion. The combined effect of the above three kinds of medical treatment is the basic aspect of the recently developed advanced technique of curing crush syndromes. A splint apparatus, constructed in accordance with the present invention, can be widely used for the medical treatment of fractures, scalds, burns, or smashes, in cases when it is highly advisable to combine immobilization with simultaneous compression and moderate cooling of an injured portion of a human body.

The present invention will be better understood from the following detailed description of a preferred embodiment thereof in a medical splint apparatus, with reference being had to the accompanying drawings, wherein:

FIG. 1 is a general schematic view of a splint apparatus, embodying the invention;
FIG. 2 is a cross sectional view of an inflatable splint body embodying the invention, taken along line II II of FIG. 1;
FIG. 3 is a cross sectional view of the inflatable splint body, shown in FIG. 1, in an operative position, and
FIG. 4 is a drive diagram of the diaphragm-type pneumatic pump of the splint apparatus fig. 1.

Referring now in particular to the appended drawings, it can be seen from FIG. 1 that a splint apparatus for medical purposes, constructed in accordance with the present invention, comprises an inflatable body 1 adapted to be filled with a working fluid, and flexible conduits 2 and 3 establishing communication between the inflatable body 1 and a heat exchange structure 4. The conduits 2 and 3 include fluid control and connection means, such as control taps 5 and 6 associated, respectively, with two-part threaded couplings 7 and 8, as is illustrated in FIG. 1; alternatively, self-closing connections can be employed.

The heat exchange structure 4 comprises an external vessel 9 receiving thereinside an internal vessel 10. The internal vessel 10 communicates with the external one 9 by means of a connecting conduit 11 having therein a throttling orifice 12. The external vessel 9 in operation of the herein disclosed medical splint apparatus is permanently filled with the working fluid, e.g., water 13 or an antifreezing composition. In operation of the herein disclosed medical splint apparatus the internal vessel 10 of the heat exchange structure 4 is filled, as such need arises, with a cooling agent through a charging opening 14, e.g., with solid carbonic acid 15. In order to maintain a desired pressure inside the internal vessel 10, the latter is provided with a pressure control valve 16, through which excessive gas produced by sublimation of the solid carbonic acid 15 escapes. For similar purposes the external vessel 9 is also provided with a pressure and relief valve 17. The external vessel 9 is ad-
ditionally provided with a discharge tap 18. The vessels 9 and 10 of the heat exchange structure 4 may also be equipped with means for connecting thereto respective pressure gauges (not shown) indicating the pressure values inside these vessels.

The working fluid can be selectively directed either into the heat exchange structure 4 and therefrom into the split body 1, or directly into the split body 1, by passing the heat exchange structure 4, for which end the herein disclosed apparatus includes a control two-way tap 19 mounted intermediate of the connecting conduit 2 and the heat exchange structure 4.

The split body 1 is made from an elastic, water-imperious material, for example, from rubber or from rubber-impregnated fabric. The external wall 20 (FIG. 2) of the inflatable splint body 1 is made from a material featuring a higher degree of rigidity than the internal wall 21 of the same body 1. The walls 20 and 21 of the inflatable splint body 1 are so connected to each other by a series of seams that there is formed inside the body 1 a tortuous zigzag-shaped internal passage 22 (FIGS. 1,2 and 3) communicating at the opposite ends thereof, respectively, with the connecting conduits 2 and 3. The external wall 20 of the inflatable splint body 1 is provided with means 23 for tightening and securing the body to or around a human limb, for example, with securing belts, cooperate with pins. The internal wall 21 of the inflatable splint body 1 is provided with a set of removable panels 24 (FIGS. 2 and 3) made of a heat insulating material, e.g., a porous plastic material. In cases when the entire limb has to be cooled, the heat insulating panels 24 are removed. In case a single specified portion of the limb upon which the splint is applied is to be cooled, the respective one or several ones of the panels 24 are removed.

In order to accelerate the process of the cooling of the injured limb onto which the herein disclosed medical splint is applied, the latter is associated with a pneumatic pump means 25 (FIG. 1) communicating with the inflatable body 1 through the conduit 3 and with the internal and external vessels 9 and 10 of the heat exchange structure 4 — through a T-pipe 26 and a conduit 27, respectively.

In the herein described embodiment of the present invention a diaphragm-type pneumatic pump is used, comprising a body 28 (FIG. 4), an intake valve 29, a delivery valve 30, a diaphragm 31 rigidly connected to a diaphragm-operating rod 32, and a spring 33. In order to effect periodic supply of compressed gas into the chamber 34 of the pump body, the pump includes a two-arm linkage comprising pivotally mounted arms 35 and 36 connected by a cut-off spring 37. The arm 35 is pivotally mounted in the slot of the rod 32. The arm 36 supports an inlet valve 38 and an outlet valve 39.

The inlet valve 38 is connected through the conduit 27 with the internal vessel 10 (FIGS. 1,4) of the heat exchange structure 4. The intake valve 29 is connected through a conduit 40 with the connecting conduit 3 of the body 1, while the delivery valve 30 is connected through a T-pipe 26 with the external vessel 9 of the heat exchange structure 4 and with the two-way control tap 19.

The herein disclosed medical splint apparatus operates as follows. The heat, derived from the working liquid, effects sublimation of the carbonic acid 15, and the latter is partially turned into a vapor state. Consequently, the pressure inside the internal vessel 10 of the heat exchange structure 4 is built up. A portion of this compressed vapor or gas flows through the conduit 11 and the throttling orifice 12 into the internal space of the external vessel 9, where the pressure is built up to a value maintained by the corresponding setting of the pressure relief and control valve 17. The pressure of the gas in the external vessel 9 drives a portion of the working fluid therefrom into the inflatable body 1 and inflates the latter. The pressure inside the splint body 1 equalizes with the pressure inside the external vessel 9 of the heat exchange structure 4. In this way the injured limb is immobilized by the splint body 1 applied thereto and compressed with a desired force preset by a corresponding adjustment of the relief valve 17.

Cooling of the injured limb can be effected by natural circulation of the working fluid along a closed path from the inflatable splint body 1 to the heat exchanger structure 4 and back to the splint body 1. In this case the working fluid in the splint body 1 is heated by the heat obtained from the injured limb, then it flows into the heat exchanger structure 4, where it is cooled down, and so on.

In the herein described embodiment of the present invention accelerated cooling of the injured limb of a human body can be effected with the help of the diaphragm-type pneumatic pump 25 which operates in the following manner. The major portion of the gas produced inside the internal vessel 10 of the heat exchange structure 4, which portion in case of natural circulation of the working liquid is let out into the ambient atmosphere by an appropriate setting of the relief valve 16, and in case of forced circulation is fed through the conduit 27 and the inlet valve 38 (FIG. 4) into the internal chamber 34 of the pump 25.

The pressure of this compressed gas drives the diaphragm 31 from the extreme upper position to the extreme lower position, whereby the working fluid delivered from the splint body 1 is forced from a chamber 41 into the external vessel 9 of the heat exchanger 4 through the valve 30 and the T-pipe 26. The rod 32 follows the motion of the diaphragm 31, whereby the return spring is compressed and the arm 35 turns from the upper position to the lower one. The cut-off spring abruptly throws over the arm 36 from the upper position to the lower one as the arm 35 changes its position. As a result, the inlet valve 38 closes and the outlet valve 39 opens. The gas that has been fed to the chamber 34 is let out into the atmosphere.

When the pressure inside the chamber 34 drops to the atmospheric pressure and the diaphragm 31 through the action of the return spring 33 is referred to its extreme upper position, the arm 35 turns from the lower position to the upper one. Simultaneously the working fluid is sucked into the chamber 41 from the body 1 through the external vessel 9 of the heat exchanger 4.

The cut-off spring 37 abruptly throws over the arm 36 from the lower position to the upper one as the arm 35 changes its position so that the outlet valve 39 closes and the inlet valve 38 opens, whereby the gas from the internal vessel 10 of the heat exchanger passes to the chamber 34.

Then the abovedescribed operating cycle of the pump 35 repeats itself.
The pneumatic diaphragm type pump 28 is shown in FIG. 4 in a final position of the working fluid delivery stroke; the dotted arrow lines indicate the direction of the flow of the compressed gas, and the solid arrow lines indicate the direction of the flow of the working liquid.

When needed, the herein described medical splint apparatus can effect separately either immobilization with compression of an injured limb, without cooling same, or else cooling of an injured limb without its immobilization and compression. This can be attained by controlling the apparatus correspondingly and by adjusting accordingly the relief control valve 17.

For transportation of the herein described medical splint apparatus, the inflatable body 1 with the connecting flexible conduits 2 and 3 is disconnected from the heat exchange structure 4 and from the pump 25. The internal vessel 10 of the heat exchange structure 4 may be filled with solid carbonic acid 15, and the working fluid should be drained from the external vessel 9. The body 1 should be filled with the working fluid and can be rolled up.

The flexible connecting conduits 2 and 3 of the inflatable body 1 should be closed by their respective taps.

What is claimed is:

1. A medical splint apparatus comprising a heat exchange means including two vessels, one of said vessels being received inside the other, a throttling orifice communicating the inside of the inner vessel with the space defined between the inner and outer vessels, a filling opening communicating with said inner vessel and a quantity of solid carbonic acid contained within said inner vessel, relief valve means connected to said inner vessel for controlling the pressure therewithin produced by gas resulting from sublimation of said solid carbonic acid, a quantity of working fluid contained with said space between said inner and outer vessels, an inflatable splint means, conduit means communicating said inflatable splint means with said space between said inner and outer vessels for feeding working fluid to and from said inflatable splint means, a portion of the gas resulting from sublimation of said solid carbonic acid passing through said throttling orifice and providing pressure on said working fluid.

2. A medical splint apparatus, according to claim 1, wherein said inflatable splint body has an internal wall and an external wall, said walls being made of respective materials of different degrees of rigidity and being interconnected with each other, so that a tortuous fluid passage is formed therebetween, said passage being in fluid communication with said heat exchange structure.

3. A medical splint apparatus, according to claim 2, further including a set of selectively removable panels made of a thermally insulating material connected to said internal wall of said splint body.

4. A medical splint apparatus according to claim 1 further including a diaphragm-type pneumatic pump means operatively connected to said conduit means to accelerate flow of cooling working fluid supplied to said inflatable splint means, and further conduit means communicating between said inner vessel and said pump means, whereby a portion of the gas produced by sublimation of said solid carbonic acid selectively operates said pump means.

5. A splint according to claim 1, wherein said inner vessel includes valve means to control circulation rate of said working fluid and time of cooling, and said outer vessel includes valve means to provide immobilization and a given pressure in the inflatable splint means.