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Lee et al.

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[54] **LEG CONSTRICTING APPARATUS**

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[52] **U.S. Cl.** ..... **128/24 R,** 128/DIG. 20

[51] **Int. Cl.** **A61h 1/00**

[58] **Field of Search** ..... 128/24 R, 64, DIG. 20, 128/327

[56] **References Cited**

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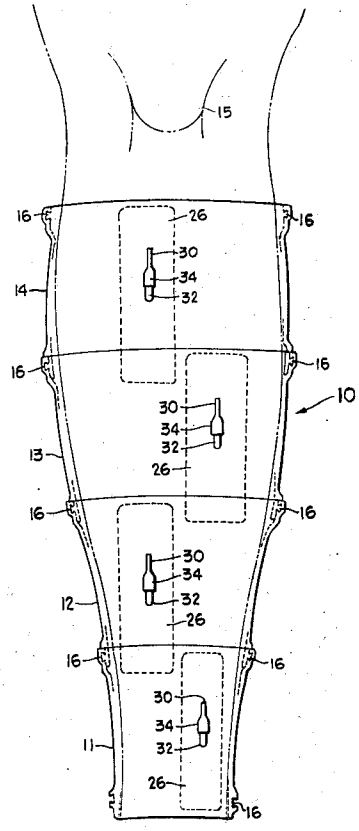
[57] **ABSTRACT**

Leg constricting apparatus includes an air pressure control system for supplying air under pressure to inflatable sacs within a plurality of elastically extensible wrappings interlocked around the lower extremity of an immobilized patient to aid in the venous return of blood to the heart and to prevent thrombus formation. Each of the plurality of elastically extensible wrappings are hooked to adjacent wrappings in overlapping arrangement around the extremity for a suitable length therealong and surrounds an elastic stocking fitted firmly over the extremity. An air inflatable sac is sewn onto the outside end of each of the plurality of extensible wrappings which envelop the sacs in folds around the extremity. Compressed air supplied from an air pressure control system is fed by conduits to a cam actuated air valve for sequentially delivering compressed air at preselected timed intervals to inflate the sacs. The sequential intermittent supply of compressed air to each of the wrappings inflates and deflates the sacs therein exerting pressure against the elastically extensible wrappings to thereby exert rhythmic pressure upon the extremity and to constrict the muscles thereof. The rhythmic constriction of the extremity muscles squeezes the blood in the veins to aid the venous return of blood to the heart.

9 Claims, 5 Drawing Figures



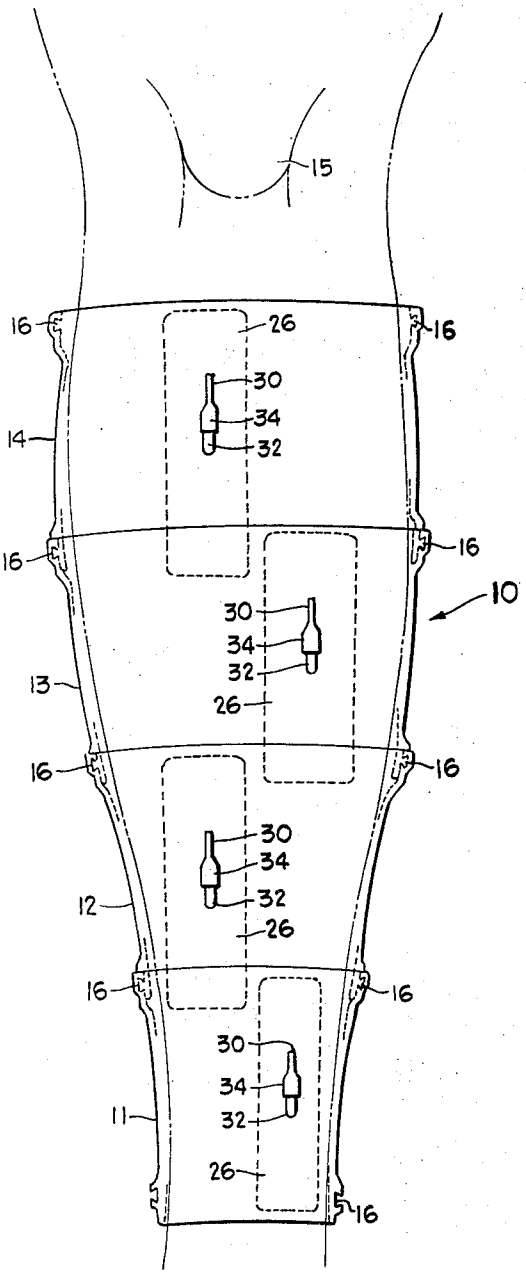


Fig. 1.

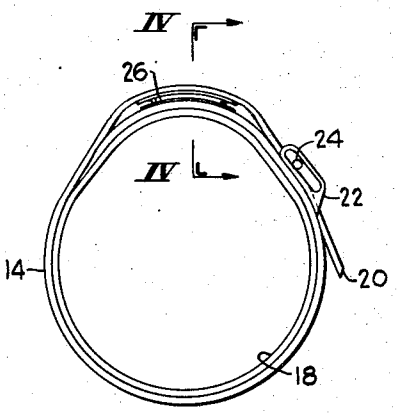


Fig. 2.

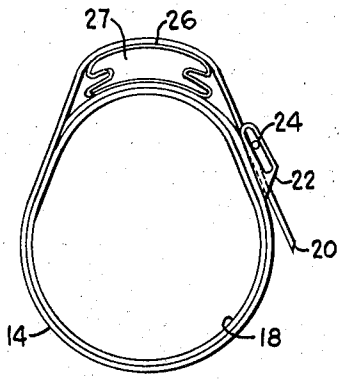


Fig. 3.

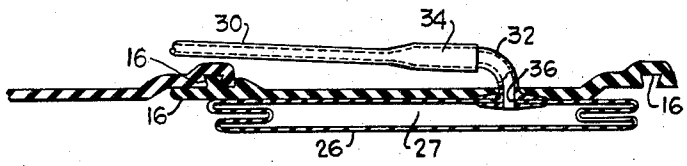

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Fig. 4.

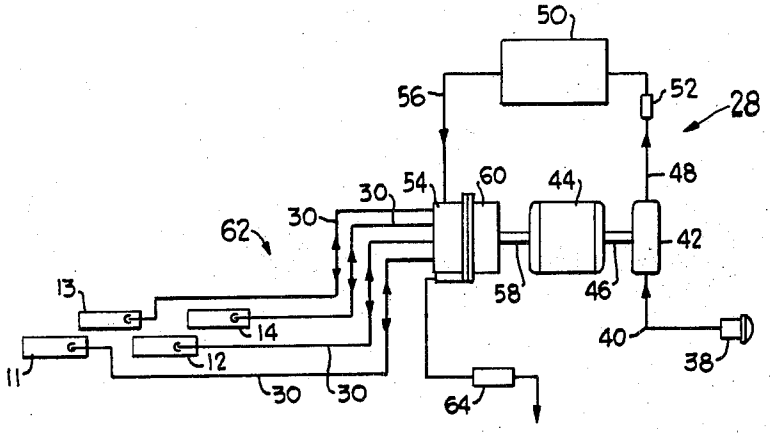
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Fig. 5.

LEG CONSTRICTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a leg constricting apparatus and more particularly to a leg constricting apparatus having a plurality of elastically extensible wrappings applied to the extremity of an immobilized patient for constricting the muscles thereof to aid in the venous return of blood when supplied with compressed air from a source.

2. Description of the Prior Art

A constant danger to a bedfast patient is the tendency to develop thrombophlebitis with formation of intravascular thrombi which may detach and flow towards the heart and lungs resulting in a pulmonary embolus which may prove fatal. With immobility, the flow of blood in the venous side of the circulatory system is reduced to a point favoring venous stasis and subsequent localized clot formation. Proximal to the adherent clot, the blood in the vein is less adherent to the vessel wall. It is usually this portion of the clot which detaches itself and acts as an embolus to the heart and lungs.

There are many situations in a hospital population where the above pertains, such as the patient who has recently suffered a heart attack, the patient in coma, the patient with a fracture, the post-operative patient who cannot be ambulated, and the burn patient. A potential danger is also during prolonged surgical procedures with the patient completely anesthetized. At present, the only methods to prevent thrombophlebitis with resultant thrombus formation are early ambulation, application of elastic hose and anticoagulant therapy (Heparin, Coumadin, Warfarin sodium, and Phenindione). Early ambulation is contraindicated in such patients who have suffered an acute myocardial infarction or fractured hip. Anticoagulants may produce bleeding especially in an early post-operative patient. The elastic hose merely constricts the musculature of the lower extremity but does not mimic the pulsatile milking action of leg muscles upon the veins which enhance venous blood flow back to the heart. It has been the practice in extreme cases, in order to increase blood supply to a local area blocked by an obstruction, to surgically remove the lesion from the artery. When there is severely diminished blood flow through the extremity, ulceration or gangrene may develop and lead to amputation.

In those cases where it is not feasible to administer anticoagulant treatment and surgery is not required, other therapy has been pursued for the purpose of increasing blood circulation through the lower extremities. In the treatment of middle-aged and elderly bedfast patients, it is a well known practice to increase the rate of blood circulation through the lower extremities by constricting the extremities through the use of elastic stockings to prevent thrombus formation. Correctly applied elastic bandages may be used in place of elastic stockings by removing and re-applying them every eight hours, checking the legs for redness, swelling and tenderness.

When there has been destruction of the valves of the deep veins within the lower extremity, a pneumatic legging of the type manufactured by Surgical Research Corporation, Rochester, New York may be prescribed.

The legging is zippered on the patient's leg and has a cloth cover and a rubber bladder inside into which air is pumped to a pressure of 30 mm. Hg. A rhythmic increase in pressure in the veins results as the patient walks. The device is intended for use in cases where the person is fully ambulatory and edema or swelling of the lower extremities is to be prevented. If the patient is unable to walk and is immobilized, no increase in pressure in the veins will occur as the extremity muscles are not stimulated. There is need for a pressure control device to be fitted on the extremity of an immobilized patient to aid in the venous return of blood to the heart for the prevention of thrombus formation. Accordingly, there is need to provide a sequential application of compressed air to inflatable sacs within extensible wrappings applied to the lower extremity for squeezing or constricting the muscles thereof to prevent stasis of blood with resultant thrombus formation in the leg veins and pulmonary emboli associated therewith.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is described and illustrated a leg constricting apparatus for aiding the venous return of blood to the heart from the veins of the extremity of an immobilized patient to prevent thrombus formation therein. The leg constricting apparatus includes an elastically extensible wrapping constructed of woven fabric that folds around the extremity in overlying relationship with an elastic stocking fitted thereon. The elastically extensible wrapping includes a plurality of interlocking segments having a longitudinal configuration. A fluid inflatable chamber is suitably secured to each of the segments adjacent a terminal end thereof. Each of the expandable chambers is enveloped within the folds of the segment applied to the extremity by interlocking means. The chamber is arranged to inflate when fluid under pressure is introduced therein to thereby expand the elastic segment and exert a constricting force upon the veins of the extremity. The segments are positioned around the extremity of a person in an arrangement in which each chamber overlaps in spaced parallel relation an adjacent chamber of another segment to form a staggered pattern of chambers and a continuous wrapping along the length of the extremity.

A valve means sequentially delivers fluid under pressure to each segment through a plurality of conduits which connect the air valve means with the inflatable chambers in each of the segments. A fluid control means for sequentially supplying fluid to each of the chambers includes a valve means for delivering fluid under pressure through the conduits to the chambers. The sequential delivery of fluid under pressure to each of the segments inflates and deflates the chambers to thereby exert a continous pressure upon the elastically extensible segments and effect constriction of the muscles of the veins within the extremity.

Accordingly, the principal object of this invention is to provide a pressure exerting apparatus applied to the extremity of an immobilized patient for constricting the muscles thereof to squeeze the veins and thereby aid the venous return of blood to the heart for prevention of blood stasis and thrombus formation in the veins.

Another object of this invention is to provide a plurality of elastically extensible segments which are easily applied to the extremity by the interlocking of adjacent segments for a suitable length along the extremity.

These and other objects of this invention will be more completely disclosed and described in the following specification, accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in side elevation of the leg constricting apparatus illustrating diagrammatically the plurality of interlocking wrappings applied around the lower extremity of a patient.

FIG. 2 is a top plan view of the leg constricting apparatus illustrating the deflated sac enveloped between the folds of the wrapping which encircle in overlying relationship the elastic stocking.

FIG. 3 is another top plan view of the leg constricting apparatus illustrating the inflated sac enveloped between the folds of the wrapping.

FIG. 4 is a cross sectional view taken along the line IV—IV of FIG. 2 illustrating the air tube leading to the inflatable sac according to the invention.

FIG. 5 is a schematic illustration of the air pressure control system for the leg constricting apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the Figures and particularly FIG. 1, there is illustrated a leg constricting apparatus, generally designated by the numeral 10 having a plurality of interlocking, longitudinal wrappings 11, 12, 13 and 14 that encircle the lower extremity 15 of a patient. Each of the wrappings 11, 12, 13 and 14, having a suitable width, is constructed of an elastically extensible woven fabric, such as nylon, to permit lengthwise extension of the wrappings and like numerals refer to like parts of each of the wrappings. The flexible wrappings 11, 12, 13 and 14 interlock with adjacent wrappings by hooks 16 in overlapping relationship. Accordingly, any number of wrappings may be interlocked for a desired length along the lower extremity.

In the illustrated embodiment as shown in FIG. 1, the wrappings are positioned between the ankle and the knee of the lower extremity but a like arrangement may be positioned thereabove or on the upper extremity. Each of the plurality of wrappings 11, 12, 13 and 14 encircle in overlying relationship an elastic stocking 18, as illustrated in FIGS. 2 and 3, that fits closely over the lower extremity 15. The elastic stocking 18 is constructed of a closely meshed cloth material that permits passage of air therethrough and around the lower extremity 15.

Each of the plurality of wrappings 11, 12, 13 and 14 having a length which is substantially greater than the width envelopes the extremity 15 in folds and is firmly applied thereon by passing the terminal end 20 through a buckle 22 positioned intermediate of the respective wrapping. The terminal end 20 is tightly secured in buckle 22 by the frictional engagement of cylindrical catch 24 with the terminal end 20. Adjacent wrappings encircle the extremity 15 in overlapping arrangement so that the hooks 16 of one wrapping catch in the hooks 16 of an adjacent wrapping to form a continuous connection that is easily detachable. In addition, the wrappings 11, 12, 13 and 14 may be joined together by using a conventional Velcro closure as described in U.S. Pat. No. 3,054,400 and U.S. Pat. No. 3,376,865.

In the preferred practice of this invention, the wrappings 11, 12, 13 and 14 are applied progressively to the lower extremity 15 of a patient with the first wrapping positioned adjacent the ankle of the lower extremity 15 and each successive wrapping 12, 13 and 14 hooked to the prior wrapping in a direction toward the knee of the lower extremity 15. The wrapping 11 is applied to the lower extremity 15 adjacent the ankle by placing the terminal end of the wrapping 11 which is adjacent the sac 26 on the lower extremity 15 and folding the wrapping 11 therearound to envelop the sac 26 within the folds of the wrapping 11. The terminal end 20 of the wrapping 11, as illustrated in FIG. 2, is passed through the buckle 22 beneath the cylindrical catch 24 to thereby urge the cylindrical catch 24 into frictional engagement with the terminal end 20. The engagement of the terminal end 20 with the buckle 22 and cylindrical catch 24 generates tension within the elastic fiber of wrapping 11 along the entire length thereof to firmly bind the lower extremity 15. To aid in the passage of fresh air in and around the enclosed lower extremity 15 each of the wrappings 11, 12, 13 and 14 has a plurality of ventilation slots (not shown) spaced in parallel relationship across the width and running longitudinally of the wrapping.

Each of the plurality of wrappings 11, 12, 13 and 14 includes an inflatable sac 26 sewn thereon adjacent a terminal end of the wrapping. The sacs 26 within the plurality of wrappings communicate with an air pressure control system 28, hereinafter described, for the sequential delivery of compressed air supplied through conduits leading to each of the inflatable sacs 26.

Referring to FIG. 4, the deflated sac 26 is illustrated within the wrapping and connected to an air tube 30. The plurality of air tubes 30 lead from a compressed air source within the air pressure control system 28 to a flexible elbow tube 32. The wrappings 11, 12, 13 and 14 are arranged on the lower extremity in such a manner that the elbow tubes 32 protrude outwardly from the sacs 26 in a longitudinal direction along the lower extremity with the enlarged diameter end section 34 projecting toward the knee of the lower extremity. The flexible elbow tube 32 joins the air tube enlarged diameter end section 34 to an opening 36 within the sac 26.

The wrapping 12 is positioned on the lower extremity 15 adjacent the wrapping 11 by engaging the hooks 16 of wrapping 12 with adjacent hooks 16 of the wrapping 11 to form a continuous connection between wrappings 11 and 12. Wrapping 12 is firmly held to the lower extremity by frictionally engaging the terminal end 20 with the buckle 22 and the cylindrical catch 24. The wrapping 12 is arranged in overlapping relationship to wrapping 11 in such a manner that the sac of wrapping 12 is laterally spaced in parallel relation to the sac of wrapping 11, as illustrated in FIG. 2. In a similar manner, as described hereinabove, wrapping 13 is applied to the lower extremity 15 to engage in overlying relationship the wrapping 12. The sac of wrapping 13 is laterally spaced in parallel relation to the sac of wrapping 12 and aligned on a line passing through the sac of the wrapping 11. The wrapping 14 is applied to the lower extremity 15 engaging in overlapping relationship the wrapping 13. The wrapping 14, as illustrated in FIG. 4, is positioned in the lower extremity adjacent the knee thereof; however, the plurality of wrappings may continue progressively upwardly on the lower extremity. The number of wrappings illustrated herein is limited

only for the purpose of description and is not intended to restrict the scope of practice of this invention.

Compressed air is supplied to the inflatable sacs **26** enveloped between the folds of each of the plurality of wrappings **11, 12, 13** and **14** by the air pressure control system **28** schematically illustrated in FIG. **5.** The air pressure control system **28** includes an air filter **38** connected by conduit **40** to air compressor **42.** Air compressor **42** is drivingly connected to a prime mover **44,** such as an electric motor, by crank shaft **46.** Conduit **48** connects air compressor **42** with the air receiver **50,** and interposed therebetween is a check valve **52** through which passes conduit **48.** Air receiver **50** communicates with a cam actuated air valve **54** by way of conduit **56.**

The cam actuated air valve is powered by the prime mover **44** and connected thereto by the output shaft **58** leading to the planetary gear reduction system **60** which is drivingly engaged to the cam actuated air valve **54.** The planetary gear reduction system **60** includes a sun gear in meshing relation with surrounding planet gears which, in turn, revolve about a ring gear (all not shown). The ring gear rotates at a lower angular velocity than the sun gear, thus providing speed reduction between the input shaft **58** and the cam shaft (not shown) of the air valve **54** for the operation thereof. An air tube assembly **62** connects the inflatable sacs **26** within each of the plurality of wrappings **11, 12, 13** and **14** to the air chamber (not shown) within the air valve **54.** An exhaust outlet **64** is provided for the expulsion of air from valve **54** when the sacs **26** are deflated by operation of valve **54.**

With this arrangement air is drawn from the atmosphere into filter **38** where particulate contaminates, such as dust particles, are filtered from the air. The filtered air passes through the conduit **40** to the air compressor **42.** The prime mover **44** imparts rotation to crank shaft **46** which is linked to a connecting rod (not shown) within the air compressor **42.** The connecting rod transforms the rotary motion of the crank shaft **46** to reciprocal motion for reciprocating the piston in the cylinders (not shown) of the air compressor **42.** The air compressed by the reciprocating motion of the piston in the cylinder within the compressor **42** is fed therefrom through conduit **48** to the air receiver **50.** The air flowing through conduit **48** and supplied to the air receiver **50** is maintained at a constant pressure therein by the operation of the check valve **52.** The check valve **52** operably prevents pressure loss within the air receiver **50** and blocks backward flow of compressed air through conduit **48** to air compressor **42.**

The air receiver **50** operably supplies air at a preselected pressure to the cam actuated air valve **54** through conduit **56.** The cam actuated air valve **54** is powered by the prime mover **44** through the input shaft **58** and the planetary gear reduction system **60** to sequentially supply compressed air at suitable, periodic intervals to the plurality of tubes **30** comprising the air tube assembly **62.** The housing of air valve **54** is adapted to receive any number of air tubes **30** for supplying compressed air from the air chamber of valve **54** to the inflatable sacs **26.**

The cam actuated air valve **54** operably supplies air at a suitable pressure to the sac **26** within the wrapping **11** through the air tube **30.** The compressed air inflates the sac **26** to form the chamber **27** therein and to exert pressure against the wrapping **11** which, in turn, constricts the muscles of the lower extremity **15.** After supplying pressure to wrapping **11** for a suitable time interval, the air valve **54** delivers compressed air to the wrapping **12** to inflate the sac **26** therein. As the chamber **27** of wrapping **12** inflates, also constricting the extremity muscle, the air vale **54** operably deflates sac **26** of wrapping **11** to release the pressure exerted on the extremity muscle. In a like manner, compressed air is sequentially delivered from the air valve **54** through the air tubes **30** to the wrappings **13** and **14** so that the vessels of the extremity muscle are rhythmically constricted from the wrapping **11** adjacent the ankle upwardly to the wrapping **14** adjacent the knee.

At any given instant during operation of the leg constricting apparatus **10** the pressure exerted against each of the wrappings **11, 12, 13** and **14** differs from the pressure exerted against the other wrappings, and the pressure exerted against the wrappings is either progressively increasing or progressively decreasing along the length of the extremity. The sequential delivery of compressed air to each of the wrappings effects constriction of the muscles of the lower extremity having a massaging effect on the veins thereof. The muscle activity stimulated by the externally applied pressure aids in the venous return of blood through the veins of the extremity to the heart. By maintaining adequate venous return, stasis of blood in the extremity with resultant thrombus formation which could ultimately result in pulmonary emboli is thwarted.

According to the provisions of the patent statutes, we have explained the principle, preferred construction, and mode of operation of our invention and have illustrated and described what we consider to represent its best embodiments. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. A leg constricting apparatus comprising,

an elastic stocking adapted to be fitted on the extremity of a patient,

a plurality of segments having a rectangular configuration with the longitudinal dimension greater than the transverse dimension, said plurality of segments longitudinally encircling the extremity in overlying relation with said elastic stocking,

interlocking means for fastening together said plurality of segments in lapping arrangement for a suitable length along the extremity,

a plurality of inflatable chambers secured respectively within said plurality of segments adjacent said elastic stocking,

fluid control means for sequentially supplying fluid under pressure to each of said plurality of inflatable chambers at preselected timed intervals, and

said chambers intermittently expandable upon the sequential delivery of fluid thereto so that pressure forces are continuously exerted upon the extremity to aid the venous return of blood from the veins of the extremity to the heart of the patient.

2. A leg constricting apparatus as set forth in claim **1** which includes,

each of said segments being fabricated of an elastically extensible woven cloth material providing for longitudinal extension thereof, and

said inflatable chambers being laterally spaced in parallel relation on said segments along the extremity of the patient.

3. A leg constricting apparatus as set forth in claim 1 which includes,
each of said chambers positioned transversely on said segments.

4. A leg constricting apparatus as set forth in claim 3 in which each of said inflatable chambers includes,
an opening extending through said chamber, and
an elbow tube protruding through said chamber opening and arranged in fluid communication with said chamber,
said elbow tube extending transversely relative to said segment.

5. A leg constricting apparatus as set forth in claim 1 in which each of said segments include,
an intermediate section,
terminal end sections at opposite ends of each of said segments,
a buckle having a slidable cylindrical catch therein secured to said intermediate section,
said inflatable chamber secured to said segment adjacent a terminal end section thereof,
said segment applied to the extremity of a patient in folds around the extremity so that said chamber is enveloped between the overlapping folds of said segment, and
one of said terminal end sections being held in frictional engagement between said buckle and said catch to retain said segment firmly around the extremity.

6. A leg constricting apparatus as set forth in claim 1 in which said interlocking means for fastening together each of said plurality of segments includes,
a plurality of hooks positioned transversely at opposite edges of each of said segments,
said hooks on one segment arranged to securely engage the hooks of an adjacent segment so that portions of adjacent segments overlap to form an extensible wrapping around the extremity for a suitable length therealong.

7. A leg constricting apparatus as set forth in claim 1 wherin said fluid control means includes,
a fluid compressor,
a prime mover drivingly connected to said compressor so that fluid supplied to said compressor is compressed to a predetermined pressure therein,
a fluid receiver,
a check valve operable to maintain said predetermined fluid pressure being supplied to said air receiver,
first conduit means for connecting in series said receiver with said compressor and said check valve interposed therebetween so that fluid under pressure is fed from said compressor to said receiver,
a valve means for supplying fluid under pressure therethrough at preselected timed intervals, and
second conduit means for connecting said fluid receiver to said valve means so that fluid under pressure is conveyed from said fluid receiver to said valve means.

8. A leg constricting apparatus as set forth in claim 7 in which said valve means includes,
a plurality of conduits arranged to provide fluid communication between said valve means and said chambers of said segments, and
said valve means operable to sequentially feed fluid under pressure to said chambers through said plurality of conduits at preselected timed intervals so that said chambers intermittently inflate and deflate to thereby exert in timed sequence continuous pressure upon the extremity.

9. A leg constricting apparatus as set forth in claim 1 which includes,
said plurality of elastically extensible segments arranged to rhythmically constrict the muscles of the extremity upon delivery of fluid to said chambers at preselected timed intervals to thereby aid the venous return of blood to the heart through the veins of the extremity.

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