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Dye

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[54] COMPRESSION DEVICE HAVING STEPPER MOTOR CONTROLLED VALVES

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[21] Appl. No.: **99,506**

[22] Filed: **Jul. 30, 1993**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 790,809, Nov. 12, 1993, abandoned.

[51] **Int. Cl.**[6] **A61B 17/12**

[52] **U.S. Cl.** **606/201**; 606/202; 606/204

[58] **Field of Search** 606/201, 202, 204

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,738,249	4/1988	Linman et al.	128/24 R
4,770,181	9/1988	Tomoda	128/648
4,838,257	6/1989	Hatch	128/204.18

FOREIGN PATENT DOCUMENTS

2104684 3/1983 United Kingdom .

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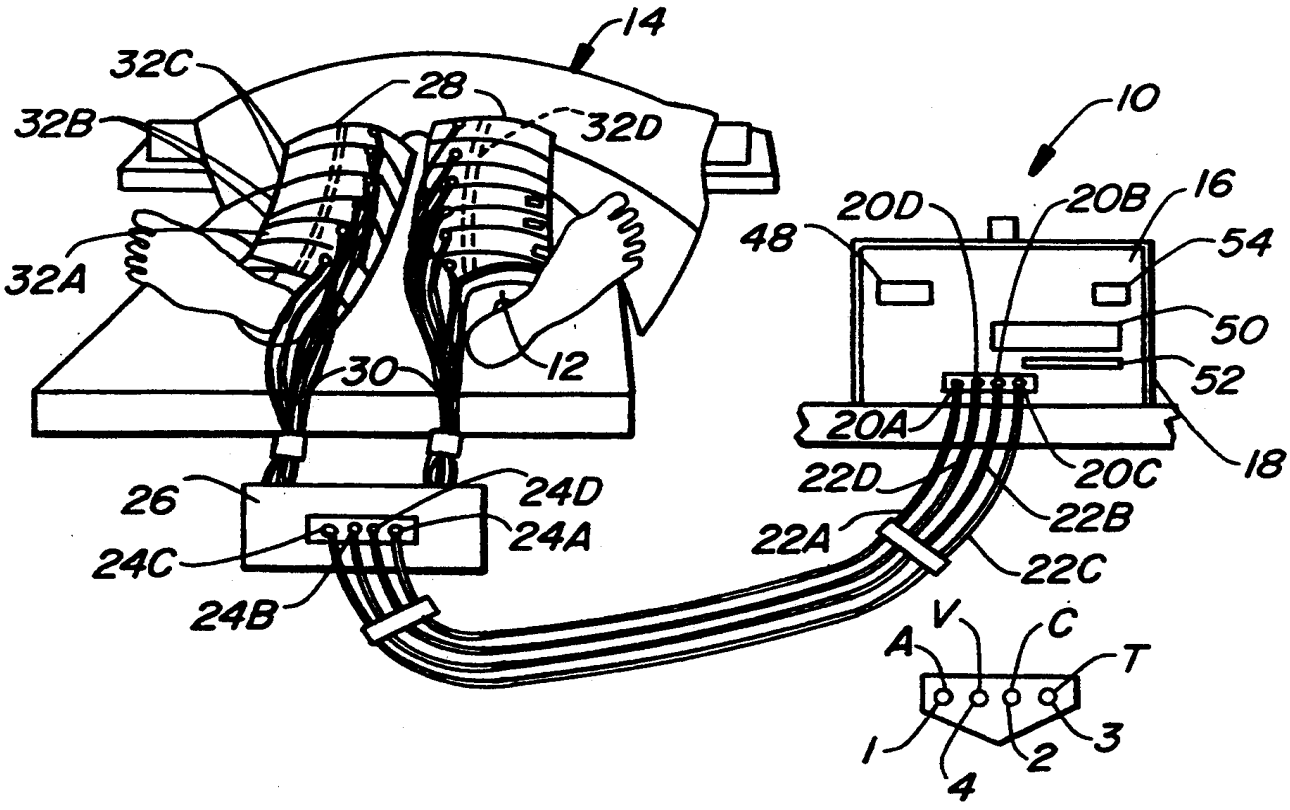
[57] **ABSTRACT**

A compression device for applying compressive pressures against a patient's limb through means of a flexible, pressurizable sleeve which encloses a limb. The compression device has a pressure control apparatus which includes a microprocessor, a driver circuit and a flow control valve having a stepper motor attached thereto. The microprocessor is programmed to control pressure to the sleeve in conjunction with the driver circuit and the flow control valve by actuating the stepper motor. The microprocessor compares a signal generated by a pressure transducer to a preselected pressure value, it then generates an electrical signal to a driver circuit which in turn sends pulses to the stepper motor to automatically adjust the flow control valve, thus, controlling the flow of fluid therethrough so as to maintain a preselected pressure applied to the limb by the pressure chamber of the sleeve.

5 Claims, 3 Drawing Sheets



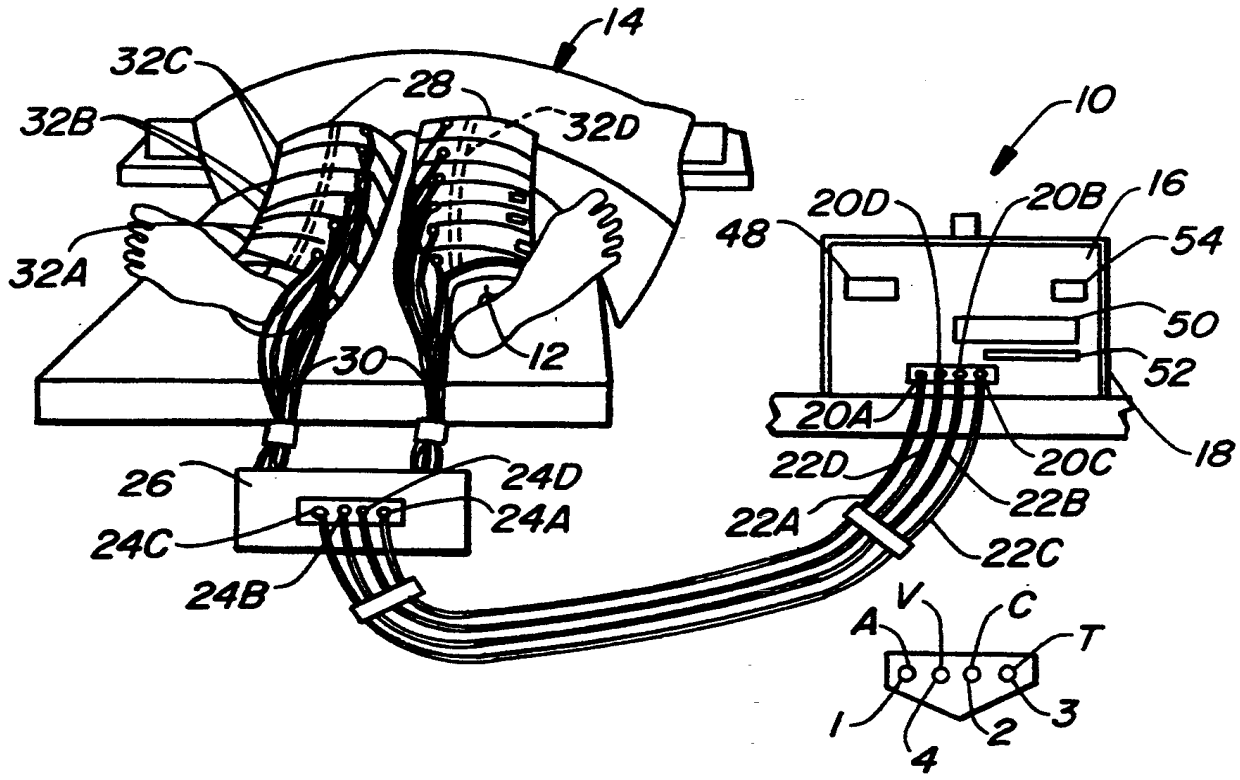


FIG. 1

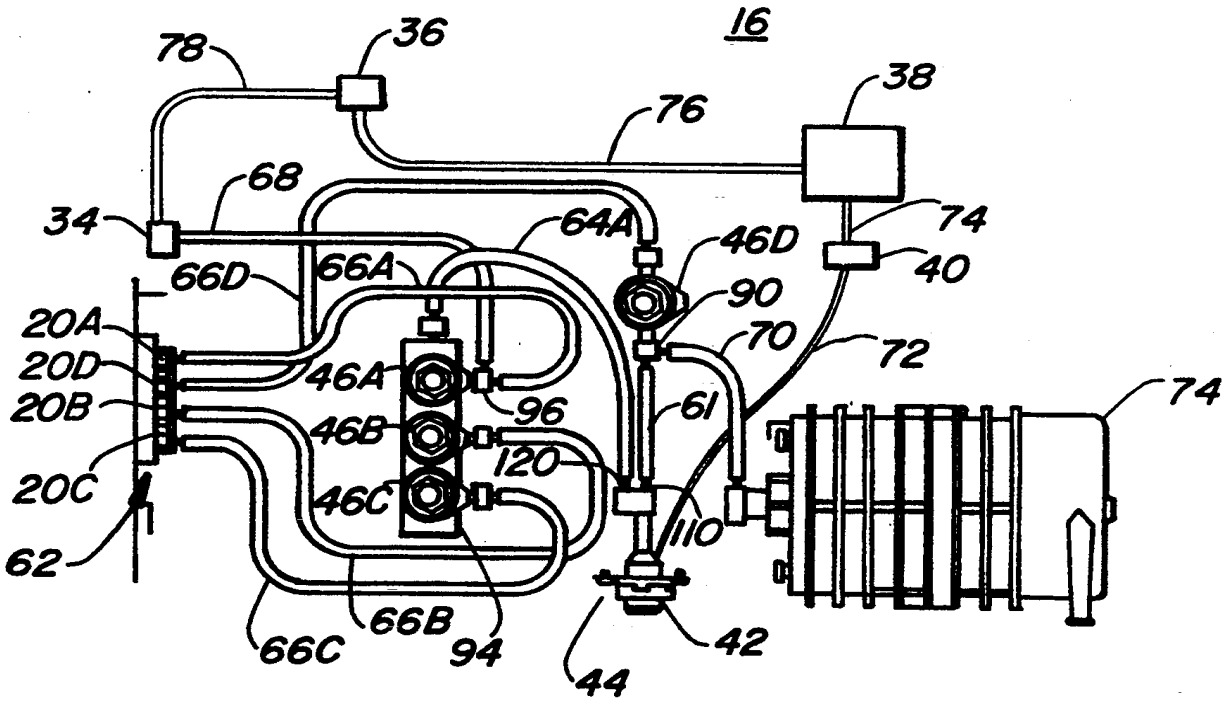


FIG. 2

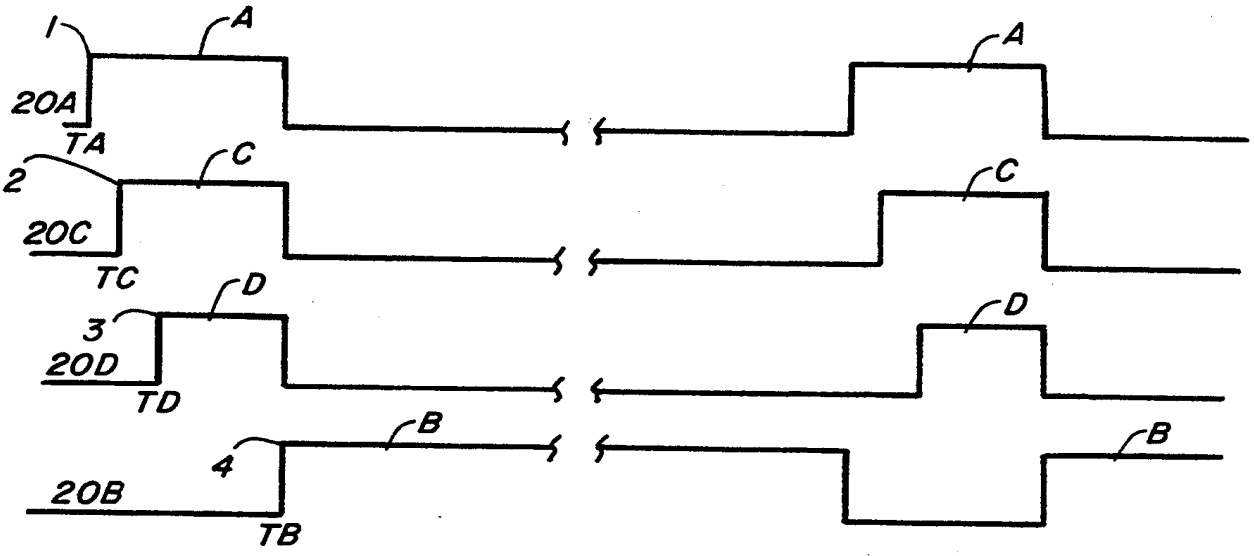


FIG. 3

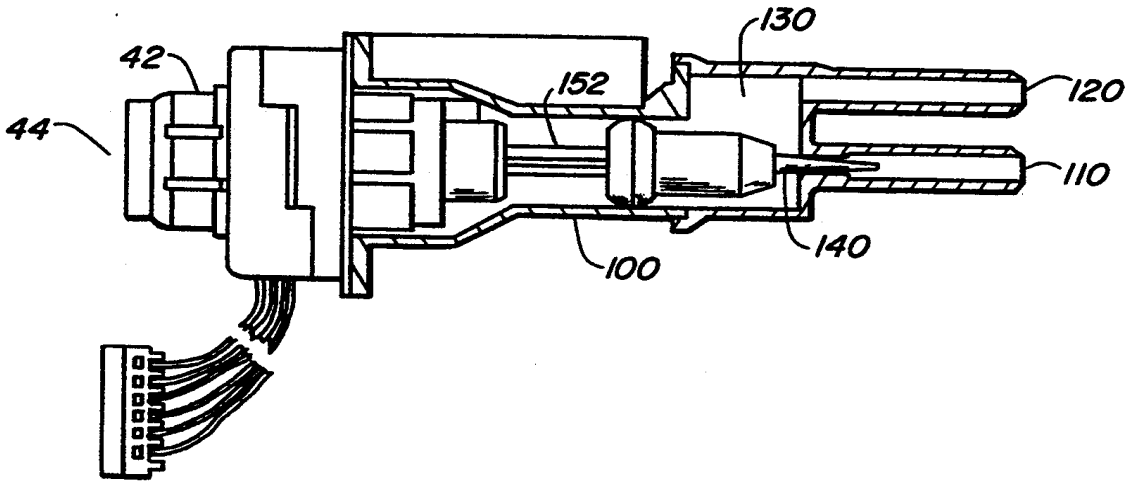


FIG. 4

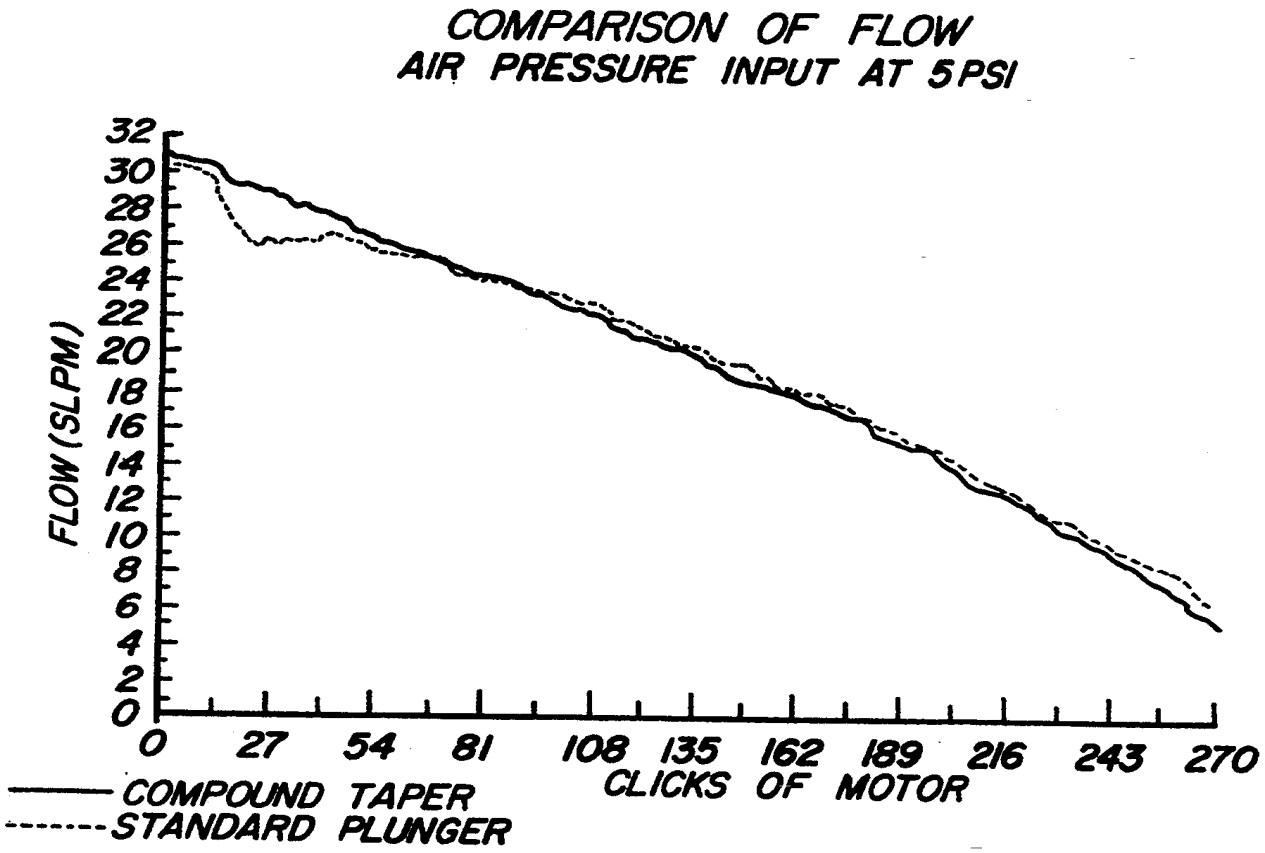


FIG. 5

COMPRESSION DEVICE HAVING STEPPER MOTOR CONTROLLED VALVES

This application is a continuation-in-part of application Ser. No. 07/790,809, filed Nov. 12, 1993 and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a device for applying compressive pressures against a patient's limb through means of a compression sleeve enclosing the limb, and more particularly, to a means for automatically adjusting the pressure applied to the sleeve to maintain a preselected pressure and to eliminate any application of excessive pressures to the limb.

2. Description of the Prior Art

Compression sleeves and devices for controlling them are well know and illustrated in the prior art in such patents as U.S. Pat. No. 4,013,069 of Hasty; U.S. Pat. No. 4,030,488 of Hasty; U.S. Pat. No. 4,091,804 of Hasty; U.S. Pat. No. 4,029,087 of Dye et al; U.S. Pat. No. 3,942,518 of Tenteris et al; and U.S. Pat. No. 2,145,932 of Israel, and reference may be had thereto for general background information on structure and utility.

Flexible compressive sleeves having a plurality of pressure compartments/chambers are wrapped around the limb of a patient and are then pressurized to apply compressive pressure to different parts of the limb. The sleeves are connected to a source of pressurized fluid which is regulated by a controller. The controllers generally operate to form pressure cycles which propel the blood upwards from the ankle towards the thigh.

Such devices can be misadjusted or drift from proper adjustment so that safe and effective pressure may not be applied to the limbs.

Prior art such as U.S. Pat. No. 4,396,010, of Arkans, U.S. Pat. No. 4,702,232, of Gardner, and U.S. Pat. No. 4,013,069, of Hasty, incorporated herein by reference, manually control the amount of pressure that is to be supplied to a patient's limb. Furthermore, although Arkans provides a method of depressurizing a pressure compartment by use of a pressure release device, Arkans method of controlling the pressure applied to the limb is still provided by a manual control.

Other prior art, such as GB 2104684 A of Thomas Mummeft, provides an electronic control circuit for regulating a dynamic pressure wave pneumatic control system, which in essence controls the activation and de-activation of solenoid valves so as to regulate the inflation and deflation of a sleeve in place around an extremity of a patient. The main components of this control circuit are comparators and a sleeve inflation dampener. The sleeve inflation dampener is a pneumatically-restrictive device typically spring actuated for regulating the flow of therethrough at a predetermined rate to a sleeve. The comparators are responsive to a predetermined pressure level signal and a transducer signal and generate control signals to solenoids which activate solenoid, and valves regulate the pneumatic control circuit. Each comparator generates a low signal when the signal from the appropriate level set unit (level set units are composed of individually adjustable voltage-dividing components) is greater than the amplified signal from a sleeve pressure transducer. Each comparator generates a high signal when the amplified signal from a sleeve pressure transducer is greater than or equal to the signal from the appropriate level set unit. The output of the comparators is connected to solenoids, so that when a solenoid receives a low signal from a comparator it will de-energize and its valve will close, and when a high signal is received the solenoid will be energized and its valve will be in an open position. The pneumatic flow from the air supply is thusly conducted to the sleeve at a rate controlled by the sleeve inflation dampener, a spring actuated device. So in essence, the control circuit of the prior art simply opens or closes solenoid valves to permit air flow therethrough to the sleeve dampener to control air flow to the sleeve. The sleeve dampener being spring actuated must be preset to permit a fixed amount of air flow to the sleeve. And, because the solenoids are either opened or closed there is no in between setting.

This is not the case with the present invention. The present invention is a distinct improvement over the prior art because a microprocessor is used in conjunction with a computer program to automatically control a flow control valve attached to a stepper motor resulting in continuous regulation of fluid flow to the pressure sleeve. The microprocessor manipulates the flow control valve to provide just the right pressure to a sleeve that is around the extremity of a patient.

Even though the prior art has accomplished the depressurizing of chambers to reduce injury to a patient's limb, the control of the pressure supplied to the pressure compartments is still very inefficient and leaves much to be desired. Thus, a nurse or operator must remain with the unit constantly until the pressure has come to a preselected value and then must frequently check and recheck the pressure unit to make sure the pressure setting remains steady. Additionally, changes in the patient's position cause changes in the effective volumes of the pressure chambers resulting in undesirable changes in the pressures in the individual pressure chambers which requires further manual adjustment. The present invention provides a constant pressure to this sleeve irrespective of the position of the patient.

The aforementioned prior art attempts to precisely control pressure applied to a patient's limb but falls short of its expectations. The reason for this failure is the inherent restrictions of the components of the apparatus used. Systems that rely on the opening and closing of solenoids to control the flow of pressure are antiquated and lag behind current technology. The present invention has advanced the art of pressure control to precisely and automatically control pressure delivered to a pressure chamber of a sleeve.

A need exists for automatic control over application of a preselected pressure to the pressure chambers of a sleeve so that that preselected pressure value is maintained, and the time required by a person to watch over a pressure monitor is further reduced. The present invention provides such an automatic control to control pressure exerted on a patient's limb.

SUMMARY OF THE INVENTION

The present invention is a compression device for applying compressive pressures against a patient's limb through means of a flexible pressurizable sleeve which encloses the limb. The device has a pressure control apparatus which includes a microprocessor, a driver circuit and a flow control valve having a stepper motor attached thereto. The microprocessor is programmed to control pressure to the sleeve in conjunction with the

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