United States Patent [19]

Arkans

[11] **4,396,010**

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[54] **SEQUENTIAL COMPRESSION DEVICE**

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[51] **Int. Cl.**[3] **A61H 1/00**

[52] **U.S. Cl.** ..... **128/24 R;** 128/24.1; 128/40

[58] **Field of Search** ..... 128/24 R, 64, 24.1, 128/38–40; 137/102, 487.5

[56] **References Cited**

U.S. PATENT DOCUMENTS

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3,896,794	7/1975	McGrath	128/24 R
4,030,488	6/1977	Hasty	128/24 R
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4,321,929	3/1982	Lemelson et al.	128/630

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[57] **ABSTRACT**

A pressure generating device for applying compressive pressures from a compressor against a patient's limb through means of a flexible, pressurizable sleeve which encloses the limb having an overpressure circuit which causes venting of the pressurizable sleeve and termination of power to the compressor in the event of the pressure assuming an excessive value. The sleeve has a ventilation chamber and a controller which generates electrical signals to actuate a solenoid controlled valve to periodically connect the compressor to the ventilation chamber during cooling cycles.

11 Claims, 4 Drawing Figures

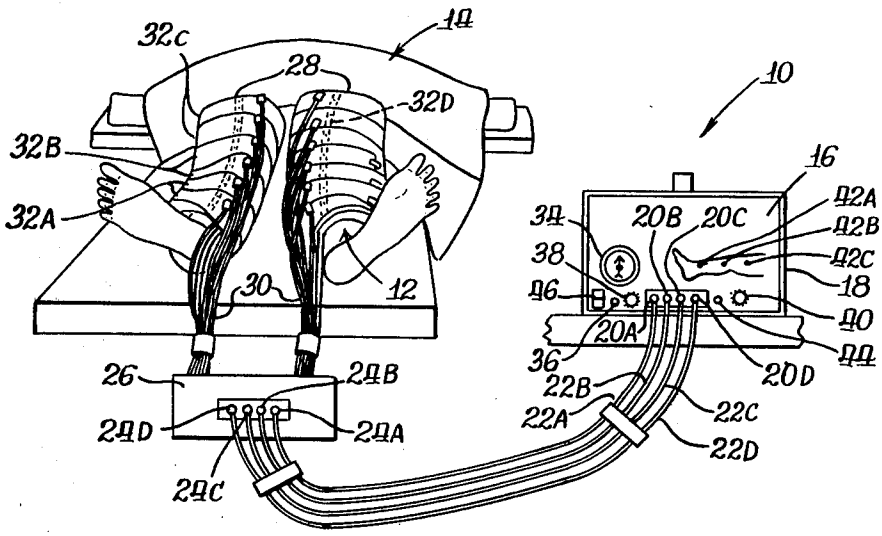


Fig. 1.

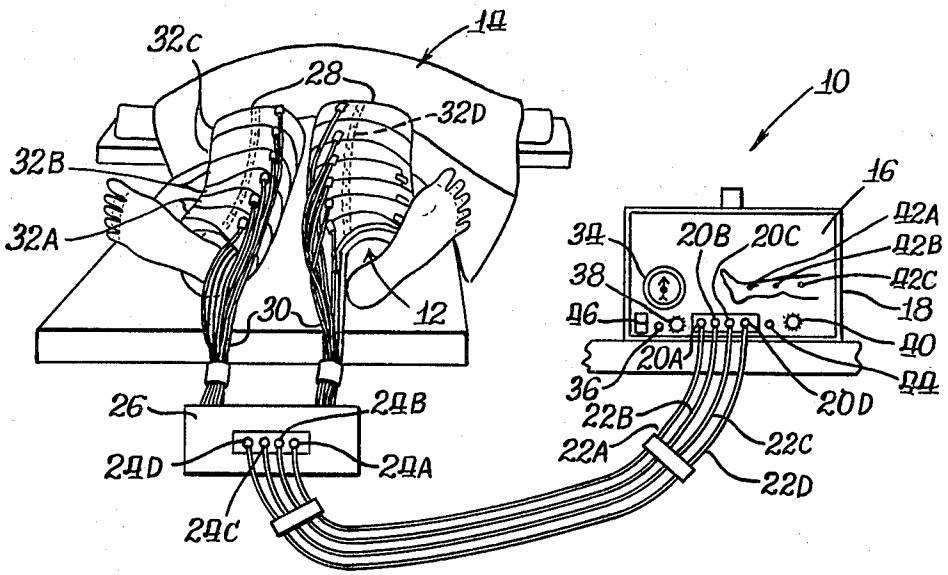
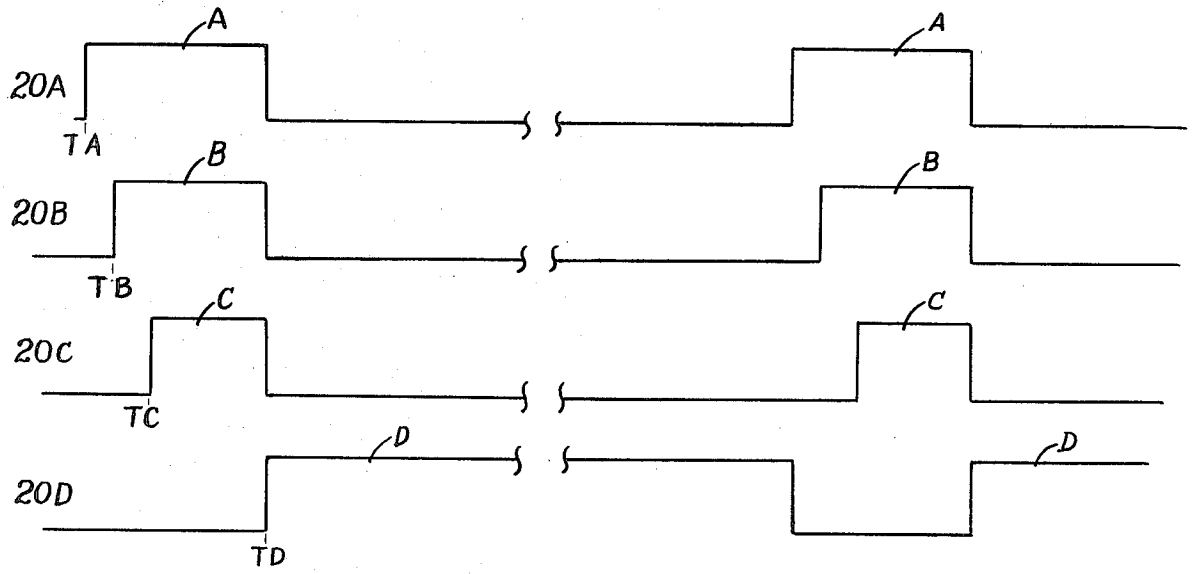


Fig. 3.



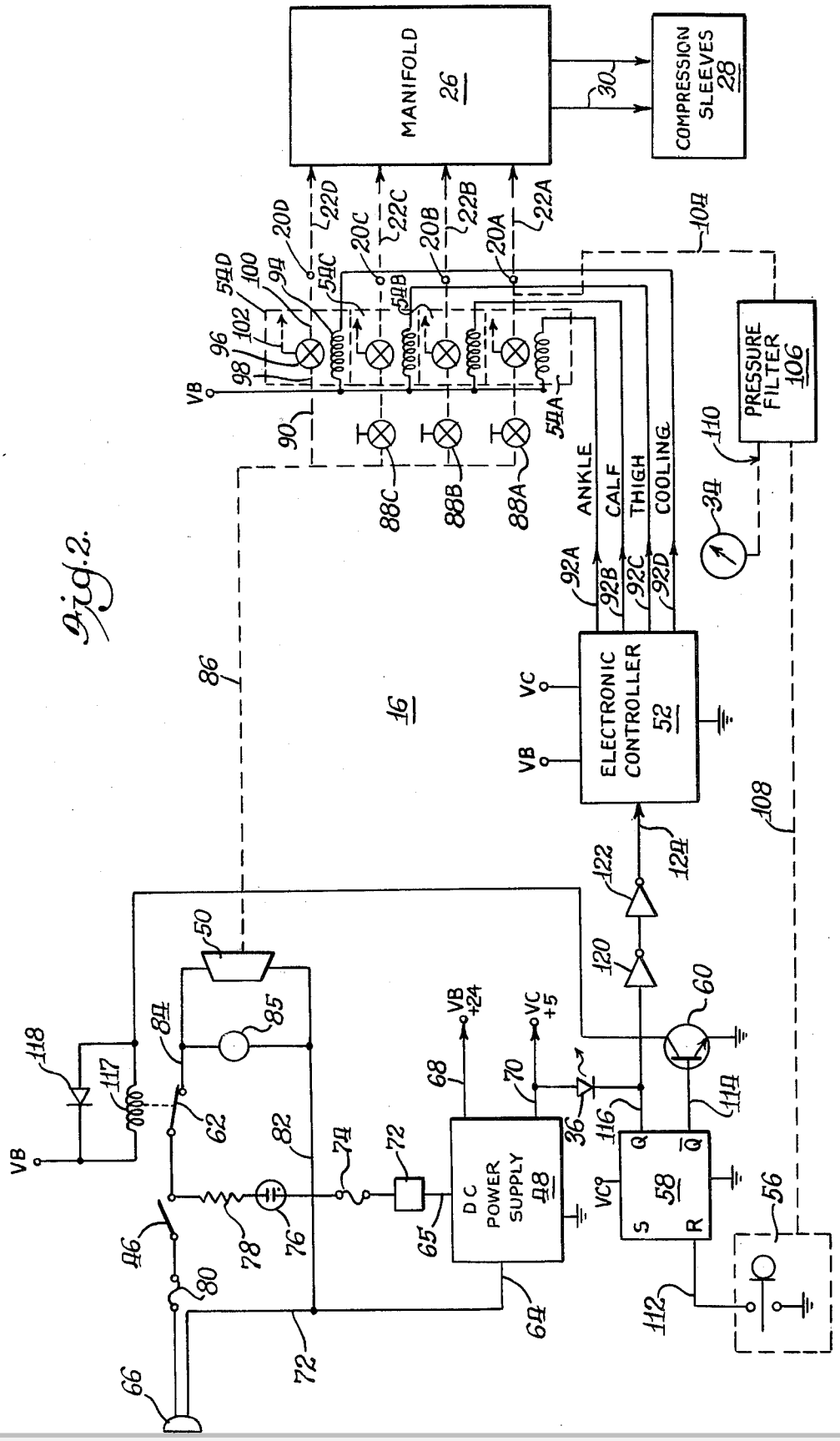


Fig. 2.

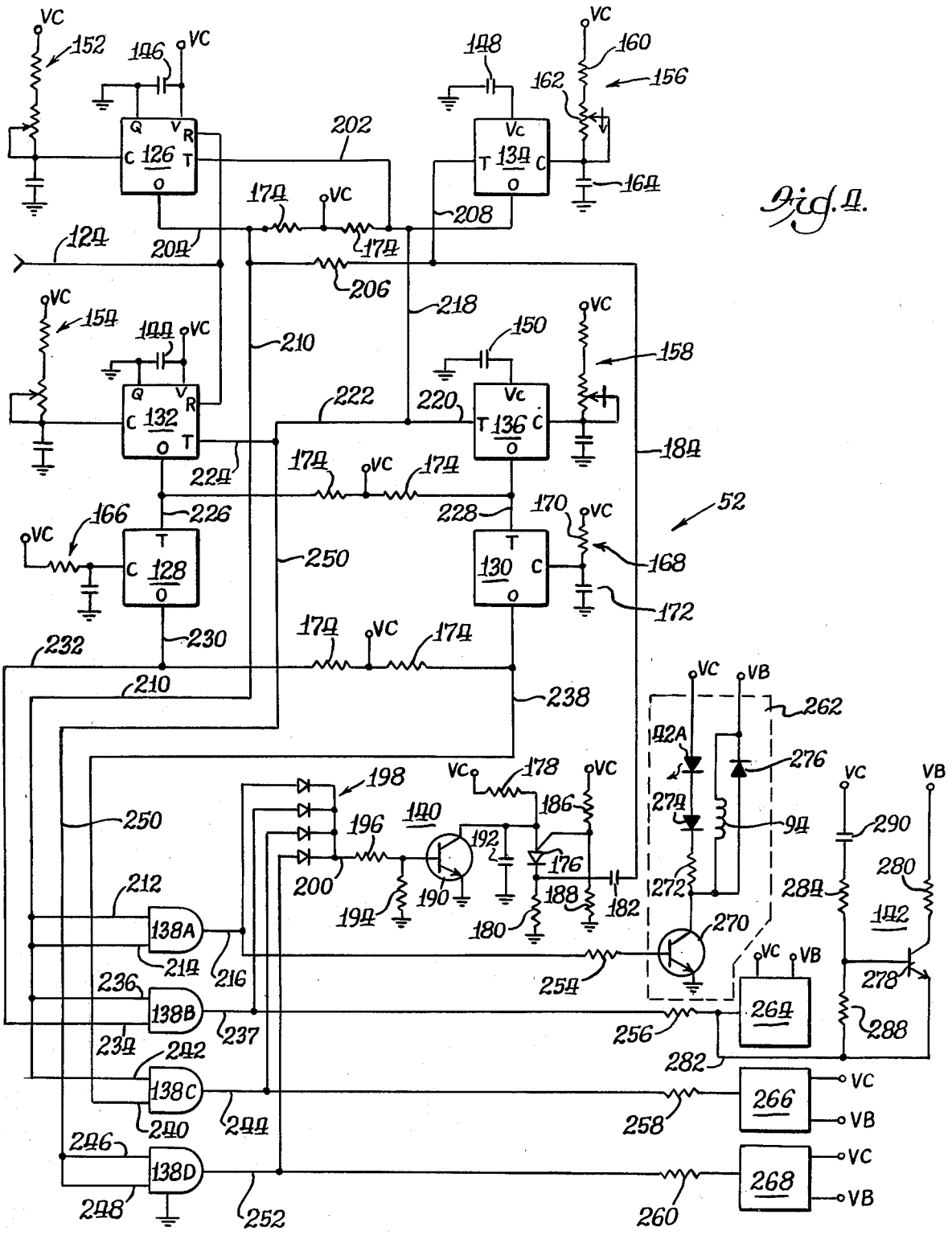


Fig. 4.

SEQUENTIAL COMPRESSION DEVICE

BACKGROUND 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 circuit for preventing the application of excessive pressure and to control the application of pressure to a ventilation chamber of the sleeve.

Compression sleeves and devices for controlling them are well known and illustrated in the patent art such as U.S. Pat. Nos. 4,013,069 of Hasty; 4,030,488 of Hasty; 4,091,804 of Hasty; 4,029,087 of Dye et al.; 3,942,518 of Tenteris et al.; and 2,145,932 of Israel, and reference may be had thereto for general background information of structure and utility.

Briefly, flexible compressive sleeves having a plurality of pressure compartments are wrapped around the limb of a patient and are then intermittently pressurized to sucessively apply pressure compression to different parts of the limb.

One potential problem with such devices is that due to malfunction the pressure can become so great as to discomfort or even injure the patient. Accordingly, in known devices such as those shown in the above patents, pressure release valves have been provided to prevent such occurrence. The release valves, however, tend to be relatively slow acting and do not function to terminate power to the compressor or other pressure source.

In U.S. Pat. No. 4,091,804, a sleeve is disclosed which is provided with a ventilation chamber having openings which face inwardly toward the patient's limb to inject air between the limb and the sleeve to ventilate or cool the limb. A need therefore exists for means to control the application of pressure to the ventilation chamber in coordination with the application of power to the pressure chamber.

Known controllers have been constructed from fluidic or pneumatic controls. While such types of controls function in an acceptable manner, they are subject to mechanical wear and other deterioration.

SUMMARY OF THE INVENTION

The proposed object of the present invention is the provision of a pressure generating device for applying compressive forces against a patient's limb through means of a flexible compression sleeve having a pressure release device with a pressure sensor and means responsive to the pressure sensor sensing an excessive pressure to depressurize the sleeve.

In keeping with this object, upon sensing an excessive pressure, a pressure switch actuates an overpressure circuit to both disable a control from periodically applying pressure to the sleeve and to terminate the application of electrical power to a compressor which supplies the pressure. The overpressure circuit has a memory which causes the disablement of power termination to continue after the pressure has decreased below the excessive pressure. An indicator light notifies the operator of the disablement.

Another object is to provide a single control for controlling the application of pressure to both the sleeve pressure chambers and the ventilation chamber. In the preferred embodiment an electronic controller controls solenoid controlled valves to selectively connect the various chambers to the pressure source.

Yet another objective is to provide a pulse generator which is substantially electrical and electronic to avoid the problems of mechanical wear.

Further objectives, features and advantages will become more apparent from a reading of the following description of the preferred embodiment and the claims.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of the sequential compression device as being used to apply compressive forces and ventilation to the legs of a patient;

FIG. **2** is a schematic diagram, partially in block form, showing the preferred embodiment of the pulse generator portion of the device;

FIG. **3** is a comparative timing diagram of the electrical pulses and corresponding resultant pressure pulses generated by the pressure generator of FIG. **2**; and

FIG. **4** is a schematic diagram of the electronic controller shown in FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1**, the sequential compression device **10** is seen as being used to apply compressive pressures and cooling to the legs **12** of a patient **14**. The device **10** includes a sequential pressure generator **16** mounted within a case **18**. Generator **16**, sequentially generates the pressure pulses illustrated in FIG. **3**, at output ports **20A**, **20B**, **20C** and **20D**, respectively. These pressure pulses at output ports **20A–20D** are respectively connected through flexible tubes **22A**, **22B**, **22C** and **22D** to input ports **24A**, **24B**, **24C** and **24D** of a manifold **26**. The manifold **26** is of the type shown and described in U.S. Pat. Nos. 4,013,069 and 4,030,488 of Hasty and has two sets of four identical output ports (not shown). The four output ports of each set are associated and are in fluid communication with the input ports **24A–24D**. The two sets of output ports are respectively connected to a pair of compression sleeves **28** by a pair of flexible sets of tubes **30**.

The pair of compression sleeves **28** are identical to each other. Each one is wrapped around one of the patient's legs **12** and has three pairs of contiguous pressure chambers **32A**, **32B** and **32C**, arranged longitudinally along the length of the sleeve. In addition to chambers **32A–32C**, each of sleeve **28** has one or more ventilation chambers **32D** with a plurality of inwardly forcing openings for ventilating the patient's leg **12**. The sleeves are of the type shown in U.S. Pat. Nos. 4,091,804; 4,013,069; 4,030,488 and 4,207,876 of Hasty, and reference may be had thereto for a more detailed description of the compression sleeves **28**.

Each of chambers **32A** are connected in fluid communication with input port **24A** through a pair of flexible tubes **30** and manifold **26**. Each of the pair of chambers **32B** and **32C** are likewise connected in fluid communication with input ports **24B** and **24C** of manifold **26**. The ventilation chambers **32D** are connected through one of flexible tubes **30** and manifold **26** to input port **24D**.

Referring now also to FIG. **3**, the pressure pulse generator **16** functions to repetitively generate pulses on its output ports **20A–20D** in the time sequence shown by the wave forms of FIG. **3**. As can be seen in FIG. **3**, the first pulse A commences at time TA and is applied to the pair of ankle chambers **32A** at the lower extrem-

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