

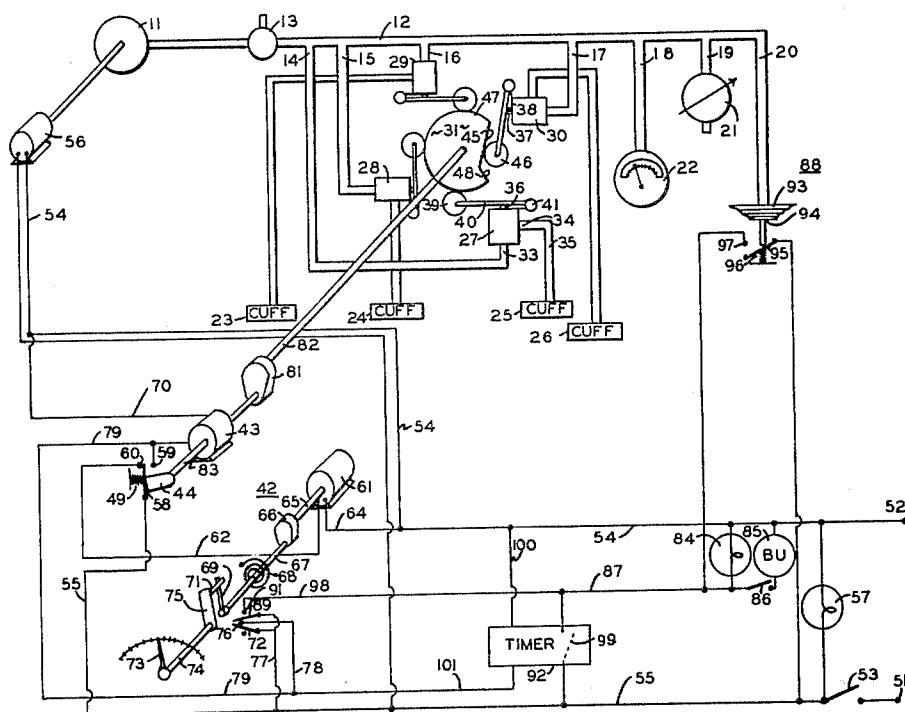
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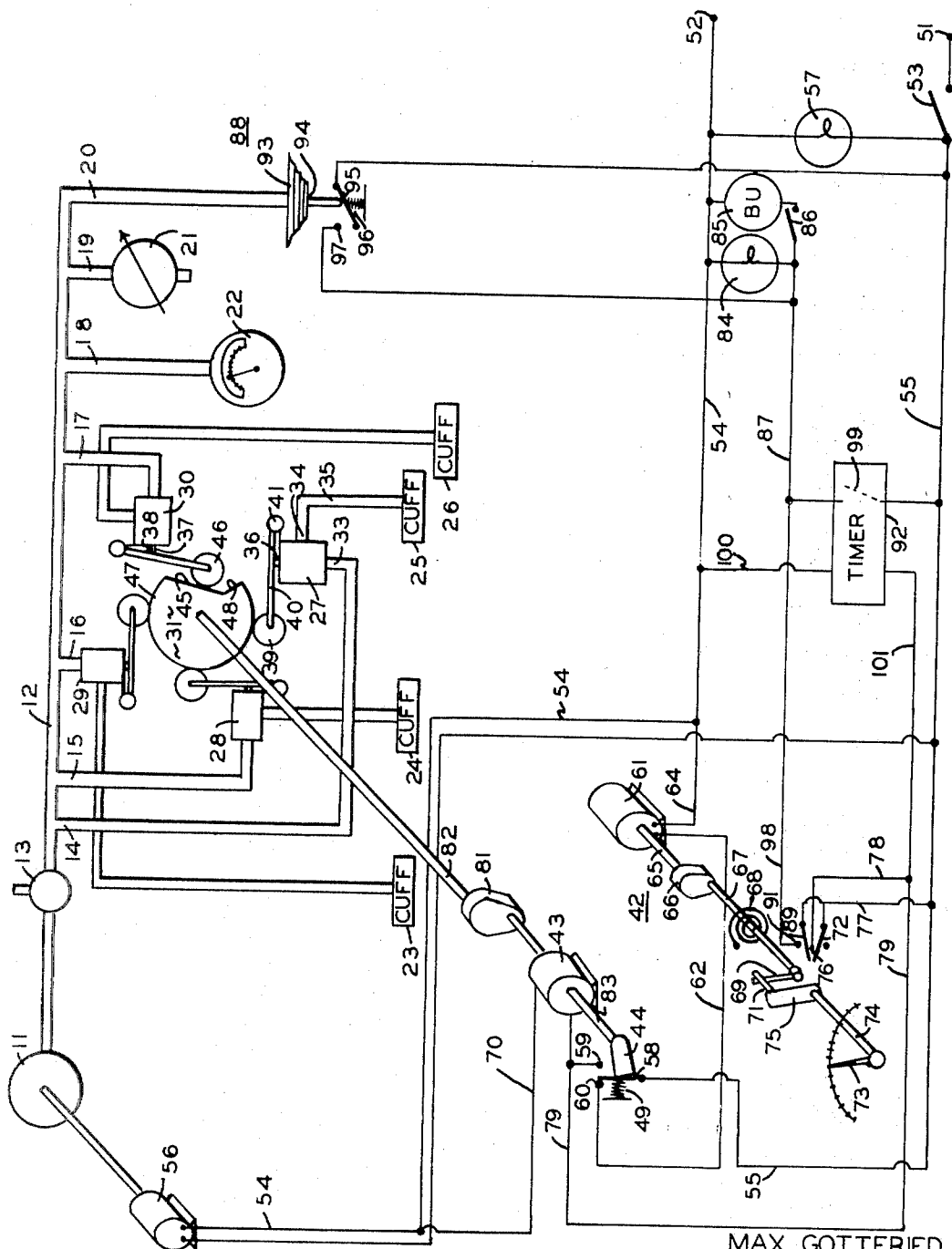
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[54] **AUTOMATIC ROTATING TOURNIQUET
 CONTROL AND ALARM**
 10 Claims, 1 Drawing Fig.

[52] U.S. Cl..... 128/24,
 128/1, 128/325
 [51] Int. Cl..... A61h 7/00
 [50] Field of Search..... 128/1,
 24, 64, 325—327

ABSTRACT: A control and safety mechanism for automatic rotating tourniquets including an adjustable timer for the treatment cycle interval. A wide range of treatment parameters are offered since the pressure applied to the patient and the time interval for the imposition of pressure to any limb are adjustable. The safety mechanism is actuated by means responsive to time cycle failures or pressure failures. It can include visual and audible alarms and can initiate operation of auxiliary treatment equipment in response to a failure of the rotating tourniquet.





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AUTOMATIC ROTATING TOURNIQUET CONTROL AND ALARM

SUMMARY AND BACKGROUND OF THE INVENTION

This invention relates to medical appliances and more particularly to a control and safety mechanism for an automatic rotating tourniquet.

Heretofore automatic rotating tourniquets have been known for the treatment of pulmonary edema associated with acute left ventricular heart failure. Such tourniquets include arm and leg cuffs which are applied to the patient and which are inflated to restrict venous return from three of the extremities at a time. This has been accomplished with a compressor regulated to the diastolic pressure of the extremities and valving means to each cuff such that three cuffs are inflated and periodically the deflated cuff is inflated while the cuff next in sequence is deflated thereby allowing venous return from the extremity to which the deflated cuff is applied. Thus no extremity is kept restricted for more than three times the cuff deflation period.

While the prior art devices have been employed with success, certain dangers remain in the case of an unattended patient including a failure to cycle the cuff inflation, and a loss of pressure as where a cuff becomes disconnected, the compressor fails or a leak develops in the pneumatic system. Further, the fixed time cycle of prior art devices may not be appropriate for certain applications particularly where the patient has a history of embolism.

An object of the present invention is to improve automatic rotating tourniquets.

Another object is to extend the range of application of automatic rotating tourniquets, particularly by affording a continuous range of time intervals for the application of pressure to limbs.

A third object is to sense and indicate various failures in an automatic rotating tourniquet system.

In accordance with the above objects one feature of this invention is an adjustable cycle timer for an automatic rotating tourniquet which provides a range for the interval of imposed constraint on each limb and the interval of the system cycle. The timer also includes an override timer arranged to track with the cycle timer whereby the failure to actuate the advance of the constraining pressure to the next extremity programmed in the system cycle within a given interval in excess of the preset interval of constraint actuates a safety device or alarm.

Another feature resides in a pressure sensitive alarm responsive to a reduction of constraining pressure in the tourniquet system below a predetermined level.

The above and additional objects and features will be more fully appreciated from the following detailed description when read with reference to the drawing showing in schematic form the electrical and fluid circuits of an automatic rotating tourniquet according to one embodiment of this invention.

DETAILED DESCRIPTION

The fluid circuit, which in a preferred embodiment is a pneumatic circuit, for an automatic rotating tourniquet comprises a pump or compressor 11 supplying a manifold 12 through a safety valve 13 which may be of the spring loaded type and is bled off to atmosphere. The safety valve 13 is preset to the maximum pressure which is to be employed by the rotating tourniquet, usually 125 mm. of mercury. The manifold 12 also is provided with a series of branch passages 14 through 20, of which branch 19 extends to a pressure regulator valve 21 vented to atmosphere and adjustably set to release at a pressure above the constraining force selected by the doctor supervising the use of the rotating tourniquet. A suitable range of pressures is between 30 mm. and 125 mm. of mercury. In practice the pressure regulator adjusting means is calibrated and is set to exceed the patient's diastolic pressure and below his systolic pressure. Branch 18 extends to a pressure gauge 22 mounted on a control panel (not shown) of the apparatus.

Pressure cuffs 23, 24, 25 and 26 are coupled to the manifold from branches 16, 15, 14 and 17 respectively through cam actuated valves 29, 28, 27 and 30 as programmed by cam 31. Typically valve 27 includes an inlet 33 from branch 14, an outlet 34 coupled as by hose 35 to cuff 25, and an operating plunger 36 which controls the valve and is biased outward by a spring (not shown) biasing the valve closed. The valve is opened when the plunger is depressed. Valve 27 has a three-way action by virtue of a bleed path (not shown) extending from outlet 34 to an axial passage (not shown) in plunger 36 and thence to ports in the side of the plunger which are open only when the plunger is extended as in the case of plunger 37 and ports 38 for released valve 30. A cam wheel 39 is journaled for rotation on an arm 40 pivoted at 41 to align a portion of the arm in operating engagement with plunger 36.

Cam wheel 31 is arranged for clockwise rotation and a clockwise sequencing of the valves in their numbered sequence. Thus the system defines a time interval in timer 42 at the end of which drive motor 43 for the programming cam 31 is placed in operation to advance the cam 31 90° and the motor control cam 44 through 360° whereby the timer 42 initiates another interval. The quadrature advance of cam 31 causes rising cam face 45 to lift roller 46 of valve 30 to the circular periphery 47 while roller 39 of valve 27 is permitted to drop along receding cam face 48. Thus pressure is removed from cuff 25 and it is deflated by bleeding through the plunger 36 to its now exposed ports corresponding to ports 38, while bleed ports 38 of valve 30 are closed and the path from manifold 12 to branch 17 to cuff 26 is opened to inflate cuff 26.

Periodic advance of the cuff inflation sequence is controlled by deflation interval timer 42 and program advance motor 43. Power is applied at terminals 51 and 52 through master control switch 53 to leads 54 and 55. With power on, the compressor motor 56 is placed in operation and pilot lamp 57 is lighted. Assume motor 43 has completed a deflation advance so that cam 44 has moved contact arm 58 from contact 59 to contact 60 to open the circuit from lead 55 to motor 43 and close a circuit from lead 55 to switch contacts 58 and 60, lead 62, motor 61, and lead 64 to lead 54. Motor 61 drives shaft 65 to reduction gearing and one-way clutch assembly 66 driving shaft 67 counter-clockwise against the bias of return spring 68 so that cam 69 is carried from adjustable stop 71 to engage switch blade 72. The time interval defined by timer 42 is proportional to the distance through which shaft 67 rotates to carry cam 69 from stop 71 to blade 72 and thus is determined by the location of stop 71. A timer adjustment represented by the pointer arm 73 on shaft 74 to crank 75 for arm 71 is calibrated so that the deflation interval can be set manually at the face of the control panel for the apparatus. Shaft 74 is in axial alignment with shaft 67 so that increases in the interval are made by moving arm 73 clockwise thereby increasing the travel of cam 69 by setting its starting point a greater arcuate distance from the blade 72.

In operation timer 42 is reset when power is removed from motor 61 by the action of return spring 68 and the release of the clutch (not shown) in housing 66. Reset causes cam 69 to be carried against stop 71. Application of power to motor 61 through blade 58 and contact 60 causes cam 69 to be driven counter-clockwise, in a preferred embodiment for an interval of from 1 minute to 9 minutes depending upon the setting of stop 71, until it engages blade 72 and carries it to contact 76. This closes a circuit to program motor 43 from lead 55 to lead 77, blade 72, contact 76, leads 78 and 79, motor 43, lead 70 and lead 54. As motor 43 rotates cam 44, blade 58 is released from contact 60 and biased to contact 59 as by spring 49 to first establish the alternate self resetting circuit for motor 43 and then permit reset of timer 42 by virtue of the removal of energizing power from its motor 61.

Gearing and a lost motion drive in housing 81 causes a quarter turn, clockwise advance of shaft 82 carrying cam 31 while shaft 83 carrying cam 44 is carried through a complete revolution. At the end of one revolution of shaft 83 cam 44 again picks up blade 58 to open the circuit to contact 59 and

motor 43 while closing the circuit to contact 60 and timer motor 61.

Any interruption of the normal program advance outlined above actuates an alarm in the form of lamp 84 and buzzer 85, provided buzzer cut out switch 86 is closed, by completing a circuit between lead 54 and lead 87. Three modes of applying power from lead 55 to lead 87 are employed. A failure of pressure as might result if a hose were pulled loose from the apparatus or a pressurized cuff results in a pressure drop in manifold 12 which is sensed by closing switch 88. A failure of the program motor to initiate an advance within a given time interval, a few seconds, following the end of a deflation interval closes blade 89 on contact 91 to connect lead 55 through 77 to 87 to actuate the alarm. If the program motor fails to complete its program advance in an allowable interval, program failure timer 92 completes a circuit from lead 55 to lead 87 to actuate the alarm.

Switch 88 includes a closed chamber 93 having a wall 94 displaced by pressure within manifold 12 to drive blade 95 against a bias spring 96 tending to close blade 95 on contact 97 and complete a circuit from lead 55 to lead 87. As pressure in manifold 12 falls below a safe minimum for operation of the cuffs, below 30 mm. of mercury, spring 96 displaces blade 95 and wall 94 upward as viewed in the drawing to engage blade 95 and contact 97. Thus any pressure failure which would render the automatic rotating tourniquet inoperative operates an alarm.

A failure of the timer to institute a program advance results in the maintenance of blade 58 in engagement with contact 60. Timer motor 61 therefore continues to rotate, thereby advancing cam 69 beyond the normal triggering position for timer 42 to carry blade 89 to contact 91. This connects lead 55 through lead 77, blade 89, contact 91 and lead 98 to lead 87 and actuates alarm lamp 84 and buzzer 85. Thus timer motor 61, cam 69, blade 89 and contact 91 constitute a program timer failure timer which tracks adjustments of the program interval to define an interval terminating shortly after the termination of the program interval as defined by engagement of blade 72 with contact 76. This failure timer is reset when drive motor 43 releases blade 58 from contact 60 at the beginning of the advance cycle for valve actuator cam 31.

In the event a program advance is initiated and not completed in a reasonable interval, timer 92 closes a circuit represented by switch 99 between leads 55 and 87. Timer 92 initiates its interval when blade 72 engages contact 76 and is maintained when blade 60 is closed on contact 59 until the completion of a program advance by motor 43. Its circuit is across leads 54 and 55 from lead 54 to 100, timer 92, lead 101, and either lead 78, contact 76, blade 72, lead 77 to lead 55, or lead 79 contact 59, blade 58 to lead 55. Timer 93 can be of any convenient type, for example a resistance-capacitance control to an electron tube or transistor. Timer 92 defines an interval somewhat in excess of the interval of motor 43 required to carry shaft 83 through one full revolution. Where motor 43 cycles in five seconds, timer 92 can be set for about seven seconds. If motor 43 completes its cycle before timer 43 completes its interval, cam 44 shifts blade 58 from contact 59 thereby opening the circuit from lead 55 to lead 95 and resetting the timer. Normally the timer 92 will reset. With an abnormal delay in program advance its closure of contact 99 actuates the alarms.

It is to be understood that the disclosed embodiment is presented for illustrative purposes and is not to be read in a limiting sense. Other valve controls, timers and alarms can be employed, other safety means such as auxiliary treatment apparatus can be actuated in place of an alarm, and other sequences and combinations can be made of controls and alarms without departing from the spirit or scope of this invention. For example, less than four limbs can be subject to the constraining means or cuffs, more than one limb can be left unconstrained in a given release interval; or all limbs can be constrained for a given interval.

We claim:

1. An automatic rotating tourniquet control for a plurality of fluid pressure actuated limb constraining means comprising, means to apply pressurized fluid to limb constraining means to reduce the return of blood from the limbs; programming means controlling said means to apply fluid to periodically relieve the pressurized fluid applied to selected constraining means on a scheduled basis; and safety means actuated in response to the failure of said programming means.

2. A combination according to claim 1 wherein said programming means includes a program timer for defining an interval a constraining means has pressurized fluid relieved therefrom; and wherein said safety means includes actuating means responsive to the failure of said program timer.

3. A combination according to claim 1 wherein said programming means includes a program timer for defining an interval a constraining means has pressurized fluid relieved therefrom; and wherein said safety means includes a program time failure timer defining a time interval extending beyond the termination of the interval defined by said program timer which is short compared to said interval defined by said program timer, means to reset said failure timer in response to the actuation of said fluid applying means by said program timer, and a safety device responsive to the expiration of said program time failure timer interval.

4. A combination according to claim 3 including means to adjust the time interval defined by said program timer.

5. A combination according to claim 1 wherein said means to apply pressurized fluid has a given time interval to transfer a constraining means between the pressurized and relieved pressure state; and wherein said safety means includes actuating means responsive to the failure of said means to apply pressure to complete an initiated transfer interval.

6. A combination according to claim 1 wherein said means to apply pressurized fluid has a given time interval to transfer a constraining means between the pressurized and relieved pressure state; and wherein said safety means includes a transfer timer having a time interval initiated upon initiation of the transfer of a constraining means between the pressurized and relieved pressure state and of a length slightly in excess of the normal interval required to complete said transfer of state, means to reset said transfer timer when said transfer of state is completed, and a safety device responsive to the expiration of said transfer timer interval.

7. A combination according to claim 1 wherein said safety means includes actuating means responsive to the reduction in pressure of said pressurized fluid available to said limb constraining means to a predetermined value.

8. A combination according to claim 1 wherein said means to apply pressurized fluid includes a source of pressurized fluid, a plurality of valves for said fluid each having a first path communicating between said source and one of said constraining means when in a first state and a second path for relieving pressure on said constraining means, a valve actuator, an electric drive for said valve actuator to advance said actuator through a cycle transferring a valve between said first and second states, a switch responsive to initiation of operation of said electric drive to maintain said drive operating for a complete advance cycle; said programming means including a program timer to define an adjustable program interval between operations of said drive for said valve actuator, and means responsive at the end of a program time interval to actuate said drive for said valve actuator; said safety means including an advance cycle timer for defining an interval slightly in excess of the time interval required for said drive to complete an advance cycle, means to reset said advance cycle timer in response to completion of an advance cycle, a program timer failure timer to define an interval terminating shortly after the termination of a program time interval, means to reset said program timer failure timer in response to initiation of operation of said drive, a pressure sensitive switch actuated when the pressure from said source to said constraining means falls below a predetermined value, and a safety device responsive to the expiration of the advance cycle timer inter-

val, to the expiration of the program timer failure time interval, and to the actuation of said pressure sensitive switch.

9. An automatic rotating tourniquet control for a plurality of fluid pressure actuated limb constraining means comprising a source of pressurized fluid; a conduit for fluid in communication with each constraining means; a valve for each constraining means in fluid communication between said source and said respective conduit for each constraining means; means to selectively set said valves in a condition to apply fluid from said source to said respective conduits and to bar fluid from said source from said respective conduits; a timer for defining the interval said means for setting said valves is maintained in a given valve control condition and initiating a transfer in said means for setting said valves at the termination

of said interval; means for adjusting the length of the interval for said timer; and an indicator for indicating the interval set for said adjusting means.

10. A combination according to claim 9 including a failure timer defining a time interval extending beyond the termination of the time interval of said first mentioned timer an interval which is short compared to said interval of said first mentioned timer; means to reset said failure timer in response to the response of said means for setting said valves to the expiration of the interval defined by said first mentioned timer; and safety means actuated in response to the termination of the interval of said failure timer.

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