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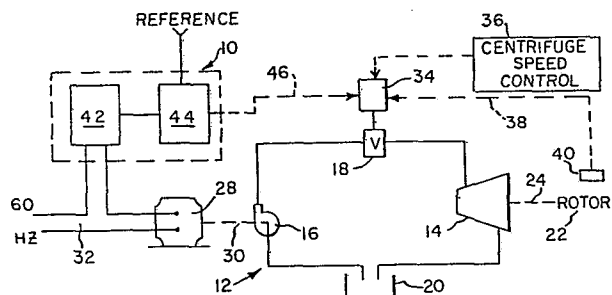
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54 **Apparatus for preventing overcurrent draw in a hydraulic turbine drive centrifuge.**

57 A motor overcurrent control arrangement for a hydraulic turbine drive centrifuge is characterized by a network (10) responsive to the current applied to the motor (28) for a hydraulic pump (16) to generate a valve control signal to control the flow of hydraulic fluid in accordance with the motor current.



TITLEAPPARATUS FOR PREVENTING OVERCURRENT DRAW
IN A HYDRAULIC TURBINE DRIVE CENTRIFUGEBACKGROUND OF THE INVENTION

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FIELD OF THE INVENTION

This invention relates to a hydraulic turbine drive centrifuge and, in particular, to a control network operative to monitor the current to the drive motor for a turbine hydraulic pump to prevent overcurrent draw.

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DESCRIPTION OF THE PRIOR ART

In a hydraulic or oil turbine drive centrifuge the motive force for rotating the rotor is provided by the passage of a pressurized hydraulic fluid through a hydraulic turbine. The hydraulic turbine is connected in series through an electrically powered pump to the hydraulic fluid supply. A flow control valve is typically interconnected in the series arrangement with the vane of the control valve being opened or closed to increase or decrease the flow of pressurized hydraulic fluid to the turbine. The flow valve is controlled by a valve controller which modulates the position of the valve vane to vary the flow rate of hydraulic fluid in the circuit supplying the turbine. The pump is powered typically by an electric motor driven by a fifty or sixty Hertz line signal.

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The motor utilized in an oil turbine drive centrifuge is typically a constant speed motor. In some instances the viscosity of the hydraulic fluid is such that in order to prime the pump the motor must draw a current in excess of that normally allotted to it. The drawing of the excess current through the motor may open the breakers provided in

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the circuitry and require the operator to continuously attempt to restart the centrifuge until the overcurrent draw is eliminated. This is believed to be disadvantageous.

5 In prior art oil turbine drive centrifuges overcurrent draw is prevented by the provision of a relief valve intermediate the control valve and the hydraulic turbine. If the hydraulic pressure within the hydraulic circuit exceeds a predetermined set
10 point, the relief valve is actuated to vent excess fluid and thereby prevent an overcurrent draw condition.

However, if the relief valve is not fully reseated leakage may occur in the hydraulic circuit
15 and maximum rotor speed cannot thereafter be achieved. The failure of the relief valve to fully reseal also prevents rapid acceleration of the rotor to operating speed. Moreover, leakage of hydraulic fluid through an unseated relief valve increases the
20 deceleration of the rotor from operating speed. Both of these effects vitiate or minimize the control effect of the valve controller on the hydraulic circuit.

It is believed to be advantageous to provide
25 an electronic arrangement to monitor the hydraulic circuit to prevent an overcurrent draw condition by the pump motor. Such an electronic arrangement is believed to allow more efficient manufacture and operation of a hydraulic turbine drive centrifuge by
30 permitting the elimination of the pressure relief valve and its attendant problems.

SUMMARY OF THE INVENTION

In a hydraulic turbine centrifuge the rotor of the centrifuge is driven by a hydraulic turbine.
35 The motive energy for the turbine is derived from the

passage therethrough of a hydraulic fluid pumped under pressure by a pump driven by an electric motor. The pump is connected in series with the hydraulic turbine through a modulating control valve typically of the vane type. In accordance with the instant invention the hydraulic circuit is monitored by monitoring the electric current applied to the pump motor and by generating a signal representative thereof. The signal is compared to a predetermined reference signal and if it exceeds the predetermined reference a valve control signal is generated to modulate the position of the valve vane to reduce fluid flow to the turbine. When the signal representative of the motor current falls below the reference signal the position of the control valve vane is not affected. In this manner the hydraulic circuit is monitored and the position of the control valve vane is modulated to prevent an overcurrent draw condition.

20 BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description thereof taken in connection with the accompanying drawings, which form a part of this application, and in which:

25 Figure 1 is a stylized schematic representation of a hydraulic turbine drive centrifuge illustrating the interconnection therewith of an overcurrent control arrangement in accordance with the instant invention;

30 Figure 2 is a more detailed schematic diagram of the centrifuge overcurrent control arrangement in accordance with the instant invention; and

35 Figure 3 is a detailed schematic diagram of a voltage comparator network utilized in connection with the control arrangement shown in Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

Throughout the following detailed description similar reference numerals refer to similar elements in all figures of the drawings.

5 With reference to Figure 1 shown is a highly stylized pictorial representation of an overcurrent control generally indicated by reference character 10 shown in connection with a hydraulic turbine drive centrifuge represented by reference character 12.

10 The hydraulic turbine drive centrifuge 12 includes a hydraulic turbine 14 connected in a closed loop hydraulic fluid circuit which includes a hydraulic fluid pump 16, a hydraulic fluid control valve 18, and a fluid reservoir 20. The turbine 14
15 is operatively connected to a centrifuge rotor 22 by any suitable drive connection schematically illustrated at 24. The valve 18 is typically a vane type flow control valve but any suitable control valve may be used. A relief valve (not shown) may be
20 interconnected in the circuit for pressure relief purposes, but not for the control of pump motor overcurrent draw. The relief valve is connected to the reservoir 20 by a suitable relief line (not shown).

25 Motive force for the pump 16 is derived from an electric motor 28 connected to the pump 16 through a suitable mechanical connection 30. The motor 28 is supplied with electric current from a standard sixty Hertz source applied over electrical conductors 32.

30 In operation electrical energy is applied to the motor 28 to rotate the pump 16 and thereby pump pressurized fluid from the reservoir 20, through the valve 18, to the turbine 14. The passage of the pressurized hydraulic fluid through the turbine 14
35 rotates the rotor 22 to the predetermined desired rotational speed.

Rotor speed is increased or decreased by increasing or decreasing the flow of pressurized fluid to the turbine 14. The speed of the rotor is controlled by a valve controller 34 which responds to input signals applied to it from a centrifuge speed control arrangement 36. The valve controller 34 is also responsive to signals applied to it over a line 38 representative of the actual physical conditions to which the rotor is exposed, as the actual rotor speed and temperature. These conditions are monitored by suitable transducers indicated generally by reference character 40.

In response to the inputs from the centrifuge speed control 36 or from the transducer 42, the controller 34 is operative to adjust the position of the valve vane to modulate the flow rate of the hydraulic fluid carried in the hydraulic fluid circuit and thereby modulate the rotor speed. Exemplary of a centrifuge having the above-described elements is an oil turbine drive ultracentrifuge such as the OTD-50 ultracentrifuge manufactured and sold by E. I. du Pont de Nemours and Company, Inc.

As noted above, in prior art oil turbine drive centrifuges motor overcurrent draw is controlled by the provision in the hydraulic circuit of a relief valve connected in series between the control valve and the hydraulic turbine. However, problems have attended the use of such a relief valve.

In accordance with this invention the motor overcurrent control arrangement 10 is associated with the hydraulic fluid circuit for the rotor 22 and is responsive to the electric current applied to the pump motor 28 to generate a valve control signal to the valve controller 34. The valve controller 34 modulates the position of the valve vane to control

the flow of pressurized hydraulic fluid to the turbine 14 in accordance with the pump motor current. Thus, the hydraulic fluid flow to the turbine is interdicted when the pump motor current
5 exceeds a predetermined threshold, or reference, level. This has the result of preventing the motor 28 from drawing excess current.

The overcurrent control arrangement 10 includes a current-to-voltage converter 42 operative
10 to monitor the current to the pump motor 28 and to generate a voltage signal representative thereof. The output of the converter 42 is applied to a voltage comparator 44. When the voltage signal representative of the current applied to the motor 28
15 exceeds a predetermined reference voltage at which the comparator 44 is set a valve control signal on a line 46 is applied to the valve controller 34. The controller 34 modulates the position of the vane of the valve 18 in accordance with the signal on the
20 line 46 and thereby controls the flow of pressurized fluid in the hydraulic circuit and limits the current drawn by the motor 28.

With reference to Figure 2 shown is a more detailed schematic diagram of the overcurrent control
25 arrangement 10 in accordance with the instant invention. A transformer 50 having a central core or bobbin 52 around the primary portion of which at least one turn of one of the pump motor input wires 32 is wound. This wound lead serves as the primary
30 coil 54 of the transformer 50. Fluctuations in the current carried in the motor input lead induce in the transformer secondary coil 56 a current signal varying in accordance with the fluctuating current in the primary coil 54. The output of the coil 56 is
35 connected to a rectifying bridge 58. Appropriate

filtering in the form of a tuning capacitor 60 is used to tune the transformer secondary 56 to the line frequency and reduce noise interference. In a typical application the tuning capacitor is valued at 5 .33 microfarads. The voltage output of the full wave rectifying bridge 58 is applied through an attenuating network 62 to the comparator 44. The attenuating network 62 includes a fixed resistors $62F_1$ and $62F_2$ connected in series with a variable 10 resistor 62V. The fixed resistor $62F_1$ adjusts the attenuation of the rectified voltage signal output from the bridge 58.

The comparator 44 is operative to compare the voltage signal applied thereto representative of 15 the pump motor current with the predetermined reference voltage level. The output from the comparator 44 is the valve control signal and is applied to the valve controller 34 over the line 46.

As seen with reference to Figure 3 the 20 voltage comparator 44 includes a precision bandgap voltage reference device 66 connected to the wiper of the variable resistor 62V. The voltage reference device 66 is connected to the input of a Schmitt trigger network 68 formed by NPN transistors 68A and 25 68B. The output of the trigger 68 is coupled through a resistor network 70 to the base of an NPN transistor 72. The collector of the transistor 72 is connected to the output line 46 leading to the controller 34. Suitable for use as the bandgap 30 reference device 66 is a device manufactured by Analog Devices Inc. and sold under model number AD589. Suitable for use as the transistors 68A, 68B and 72 are NPN transistors sold under model numbers 2N4124 by Motorola, Inc..

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When the voltage on the wiper of the variable resistor 62V exceeds the base-emitter junction voltage of the transistor 68A plus the breakdown voltage of the bandgap voltage reference device 66 (which voltage drops together define the predetermined voltage reference signal), the transistor 68A begins to conduct, thus switching off the transistor 68B. When the transistor 68B turns off, the transistor 72 becomes conductive, thus generating the control signal on the line 46 to the valve controller 34 to close the valve 18.

Depending upon the magnitude of each rectified half cycle of motor current, a square wave pulse of a corresponding duration is generated. The width of the pulse output on the line 46 is related to the current to the motor during that half cycle. These relationships are graphically illustrated by the input current and output voltage waveforms respectively shown on Figures 2 and 3. As long as the line current (and its corresponding voltage) exceed the voltage reference signal, a square wave signal is output on the line 46. The presence of the signal on the line 46 closes causes the controller 34 to modulate the position of the valve vane and to move the valve vane toward the closed position. Of course, if the voltage on the wiper of the variable resistor 62V is less than the voltage reference signal, the output signal on the line 46 is not present. When the signal is not present on the line 46, the position of the valve vane is controlled by the controller 34 in accordance with the other inputs thereto. By causing the valve vane to move toward a closed position only when the signal is present on the line 46, the control arrangement 10 modulates the valve vane position in accordance with pump motor

current only as necessary, i.e., on a duty cycle basis. Since the network 10 controls the position of the valve vane on a fast response "duty-cycle" basis servo control dynamics are avoided.

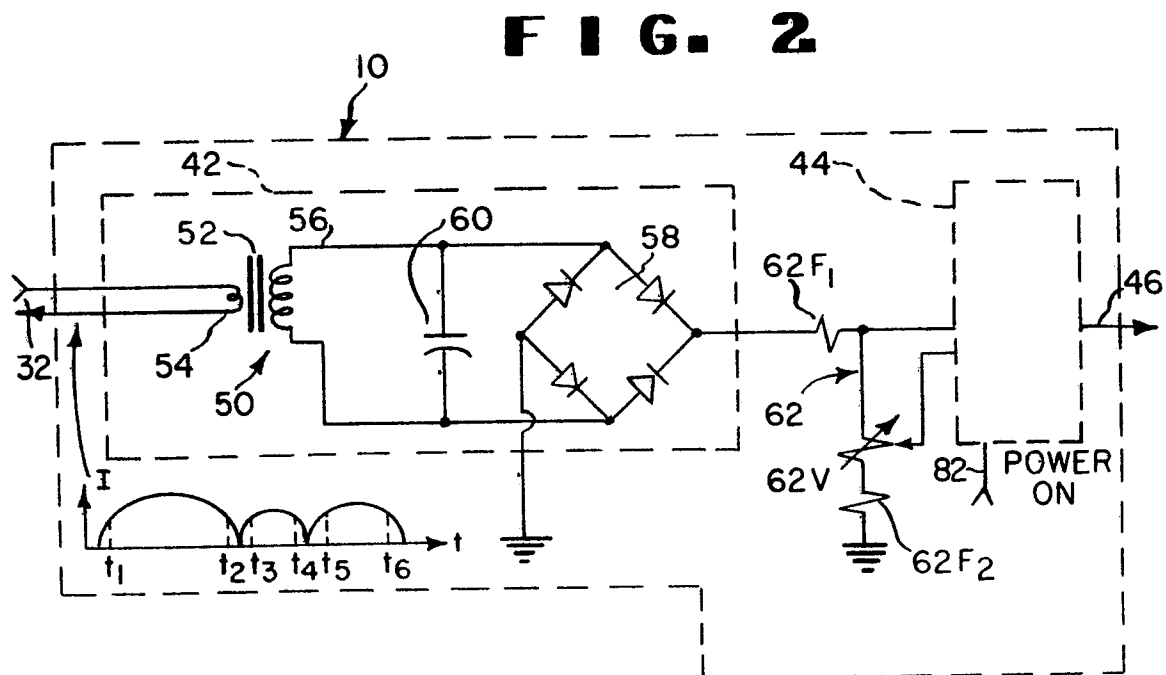
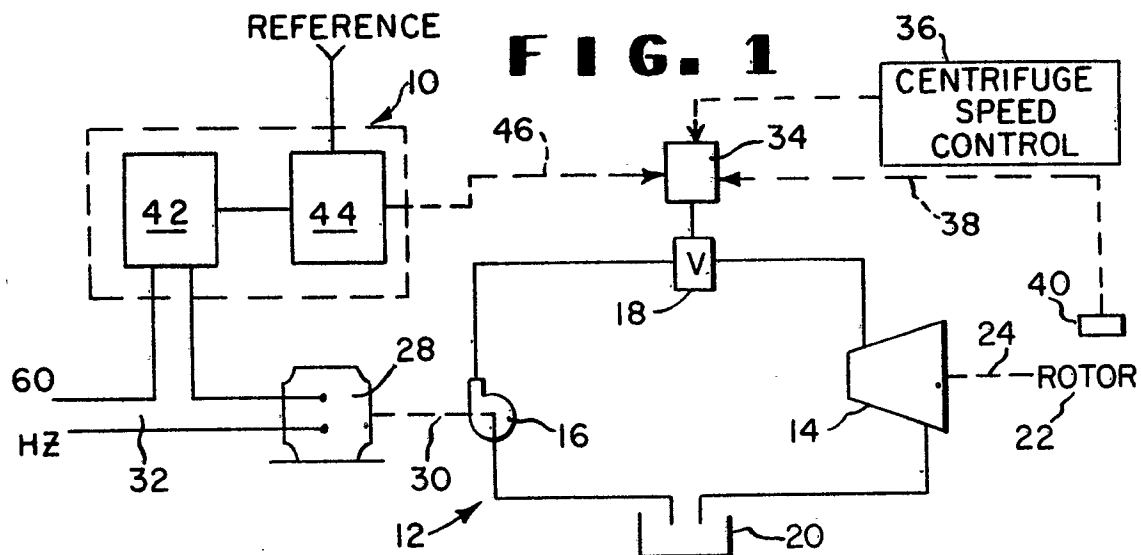
5 A time delay network 76 shunts the transistor 72. The delay network 76 includes an N-channel enhancement mode FET transistor switch 78, such as that sold by Siliconex Inc. under model number VN10KM. The gate electrode of the switch 78
10 is connected through a time delay network 80 (formed of a resistor 80R and a capacitor 80C) to a connector (not shown) and is thereby responsive to the application of full power to the centrifuge. The leading edge of a "power-on" signal on a line 82
15 turns on the transistor 78 to disable the transistor 72. As the capacitor 80C discharges in accordance with the time constant of the network 80 the transistor 78 turns off. In a typical application the resistor 80R is a ten megaohm resistor while the
20 capacitor is valued at .47 microfards. The time delay allows the centrifuge speed control network 36 to complete initialization before the current limiting network of the instant invention becomes effective.

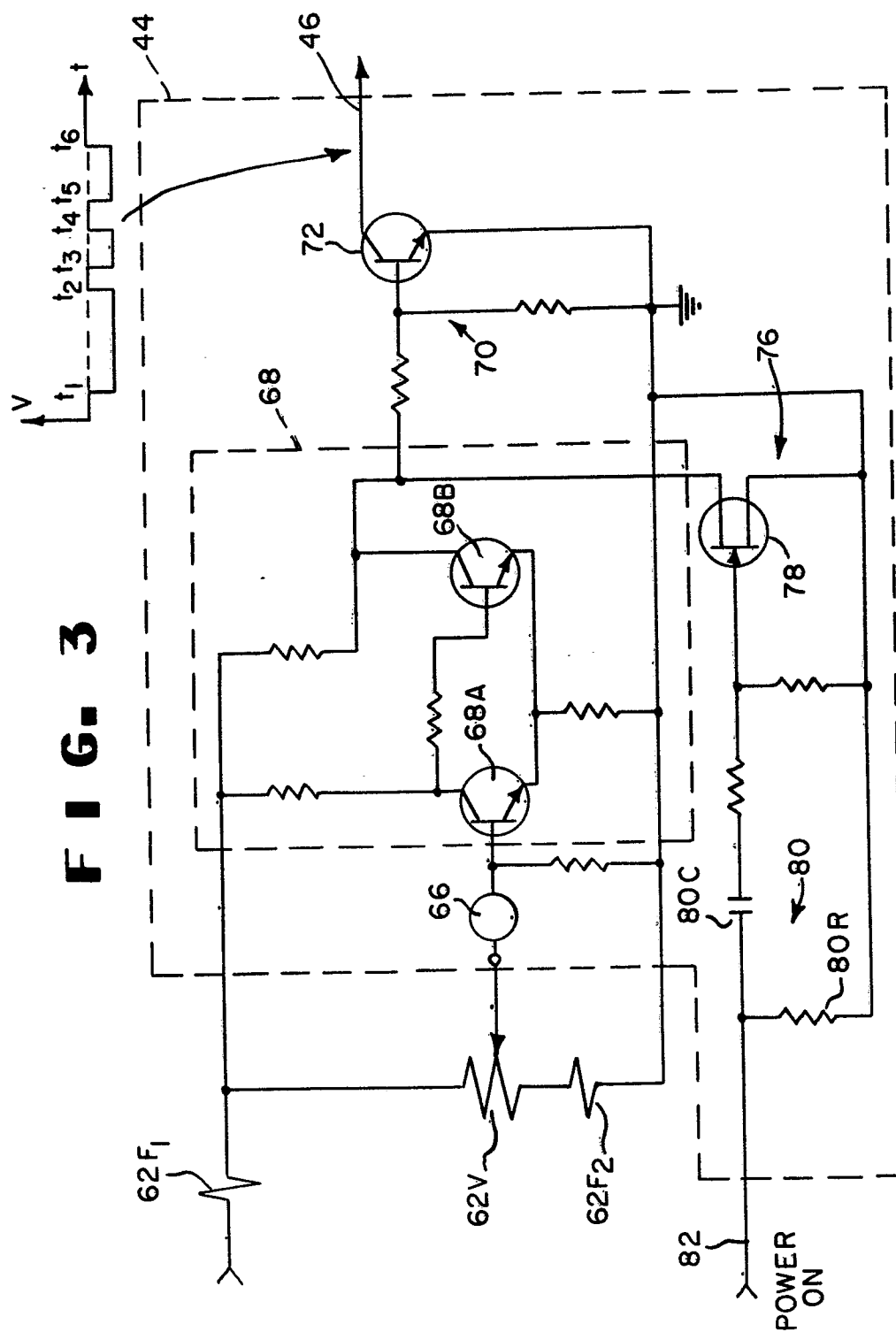
25 Having described the preferred embodiment of the invention those skilled in the art will realize and appreciate any number of modifications which may be effected thereto. It is understood, however, that such modifications lie within the contemplation of
30 the instant invention as defined in the appended claims.

WHAT IS CLAIMED IS:

1. In a hydraulic turbine drive centrifuge the motive energy for which is derived from a pressurized hydraulic fluid pumped by a pump (16) primed by a motor (28) operable by an electric current, the hydraulic turbine (14) having a modulating valve (18) connected in series therewith, the modulating valve being operable to control the flow of hydraulic fluid to the turbine, the improvement which comprises:
 - a valve control signal generating network (10) responsive to the current applied to the motor (28) for generating a valve control signal to control the flow of hydraulic fluid to the turbine in accordance with the current applied to the motor.
2. The centrifuge of claim 1 wherein the valve control signal generating network (10) comprises:
 - means (42) interconnected with the motor (28) and operative to generate a first electrical signal representative of the magnitude of the current applied thereto; and
 - a comparator (44) for comparing the first electrical signal with a predetermined electrical reference signal to generate the valve control signal when the first electrical reference signal exceeds the predetermined electrical signal.

3. The centrifuge of claim 1 wherein the valve control signal generating network comprises:
 - a current-to-voltage converter (42) responsive to motor current to generate a first voltage signal representative of the magnitude of the motor current; and
 - a comparator (44) operative to compare the first voltage signal with a predetermined reference voltage signal and to generate the valve control signal when the first voltage signal exceeds the predetermined reference voltage signal.
4. The centrifuge of claims 2 or 3 further comprising a time delay network (76) operative to disable the valve control signal generating network (10) for a predetermined delay time.
5. The centrifuge of claim 3 wherein the current-to-voltage converter (42) comprises a transformer (50) having a first and a second coil (54,56), the first coil (54) being connected to a line (32) carrying the motor current and the second coil (56) being connected to a rectifying bridge (58).







DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	FR-A- 926 838 (THE WESTERN STATES MACHINE) * Page 2, lines 22-53; page 3, lines 10-101; page 4, line 37 - page 6, line 54; figures 1-4 *	1-3,5	B 04 B 9/10 H 02 P 7/00
Y	--- GB-A-1 159 491 (AMERICAN FACTORS ASSOCIATES) * Page 1, lines 32-43; line 70 - page 3, line 14; figures 1,2 *	1-3,5	
A	--- US-A-3 504 794 (D.M. THOLL et al.) * Column 3, line 30 - column 4, line 51; figure 3 *	1	
A	--- US-A-4 004 204 (H. HOVES et al.) * Column 2, line 37 - column 3, line 33; figure 1 *	4	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 04 B 9/00 B 04 B 13/00 H 02 P 7/00 F 16 H 41/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 09-09-1982	Examiner POINT A.G.F.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			