March 31, 1970 P. RIVA ET AL 3,503,433

CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

Filed Sept. 7, 1966 6 Sheets-Sheet 1

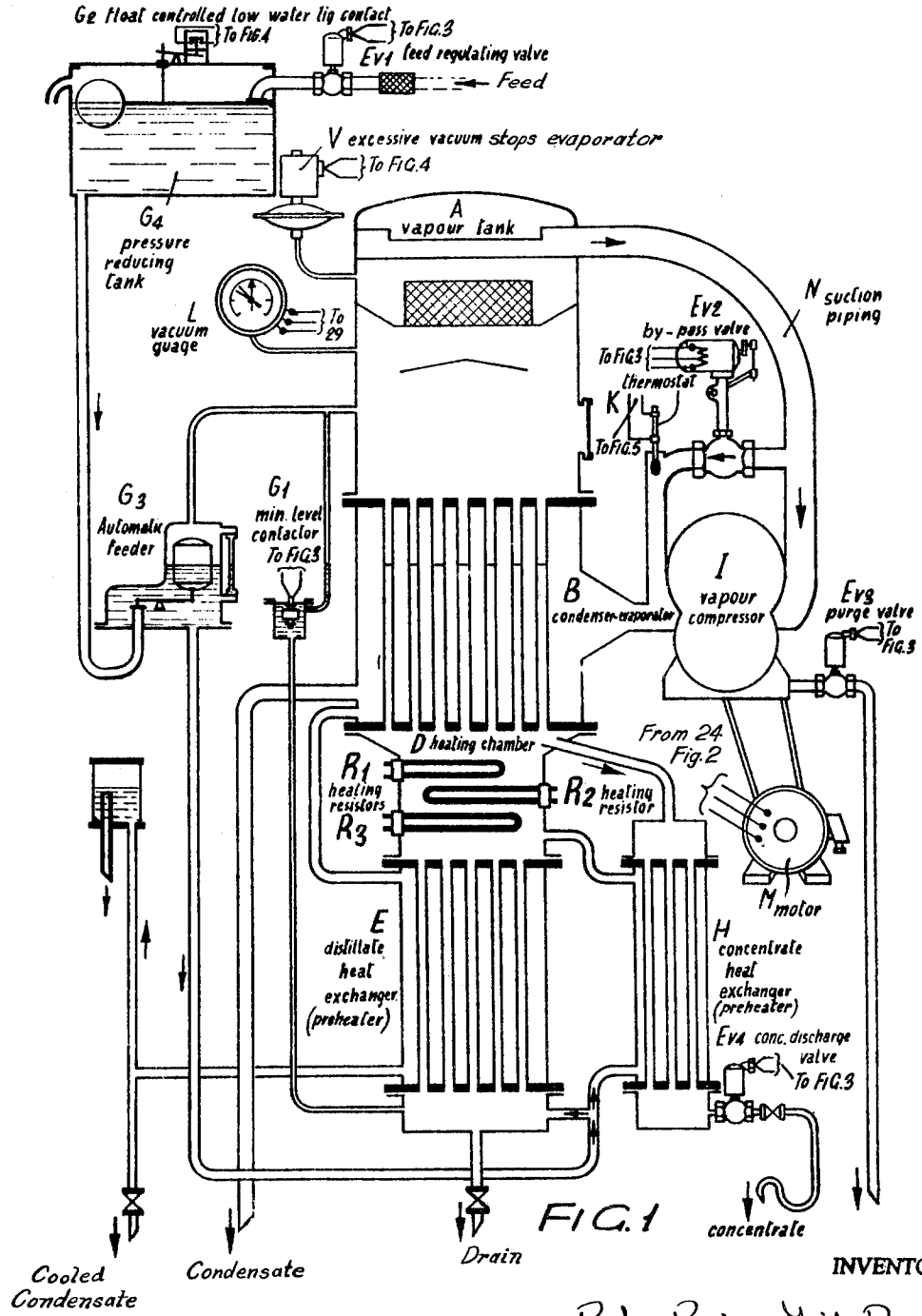

FIG. 1

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CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

Filed Sept. 7, 1966 6 Sheets-Sheet 2

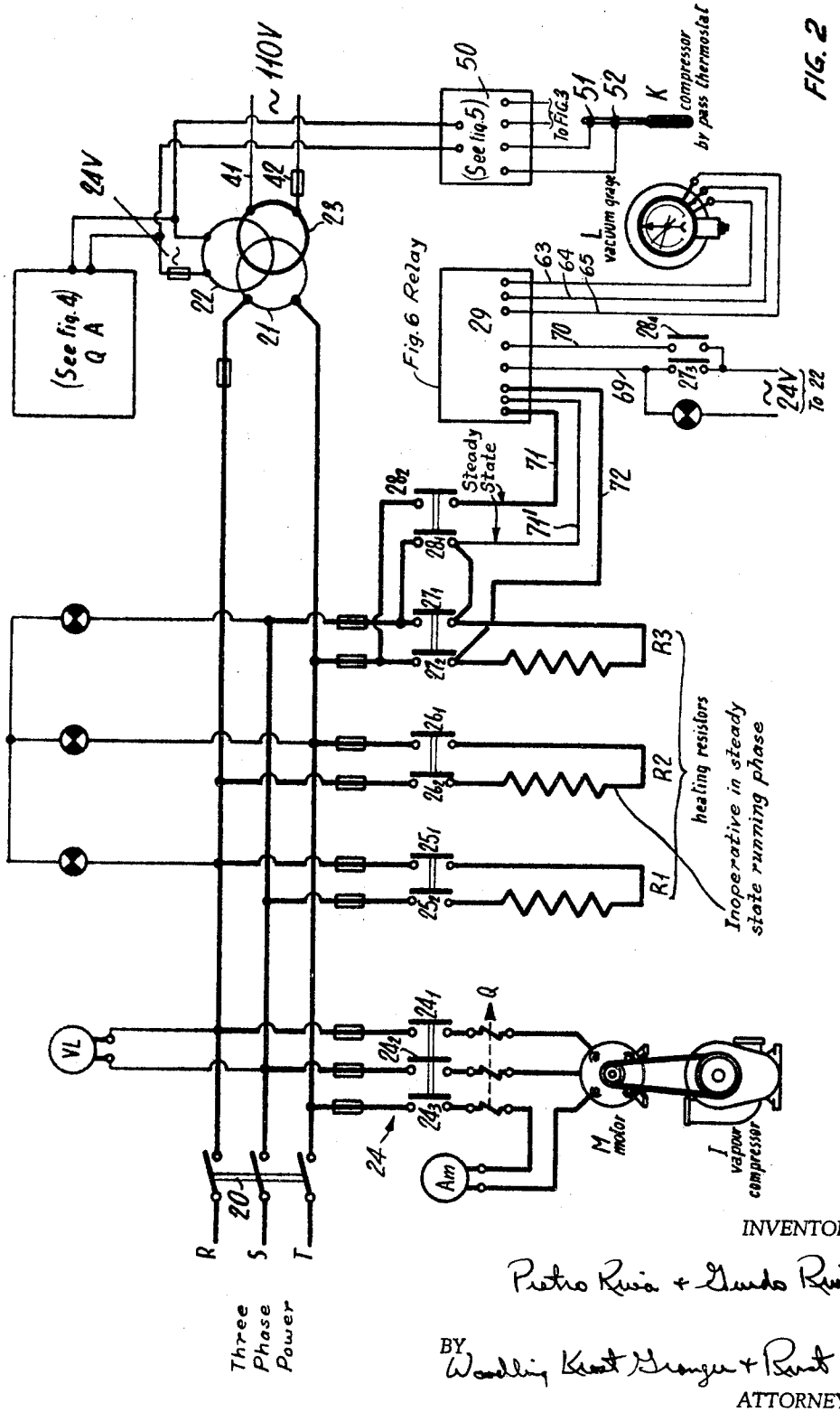

FIG. 2

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CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

Filed Sept. 7, 1966 6 Sheets-Sheet 3

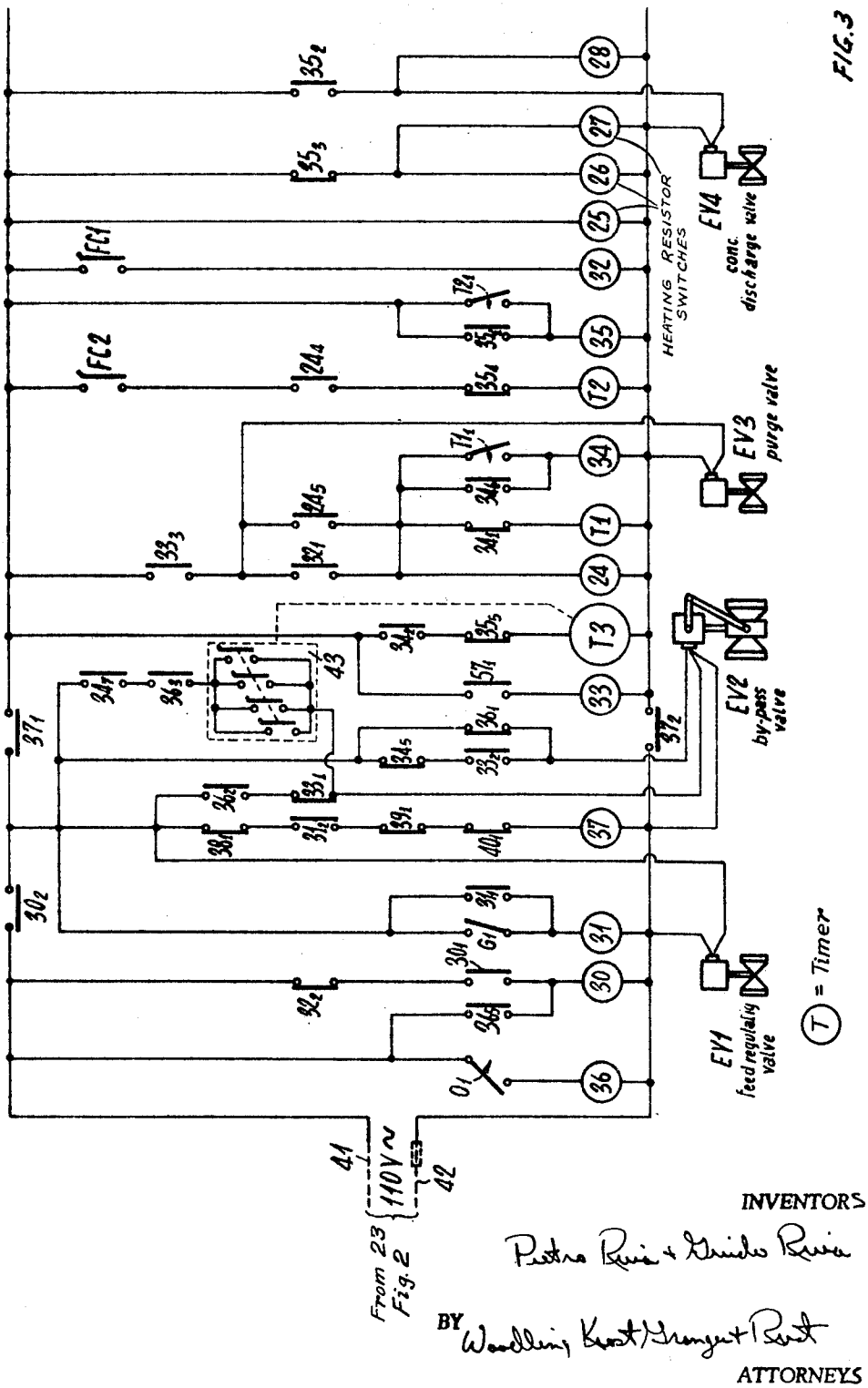

FIG. 3

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March 31, 1970 P. RIVA ET AL 3,503,433

CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

Filed Sept. 7, 1966 6 Sheets-Sheet 4

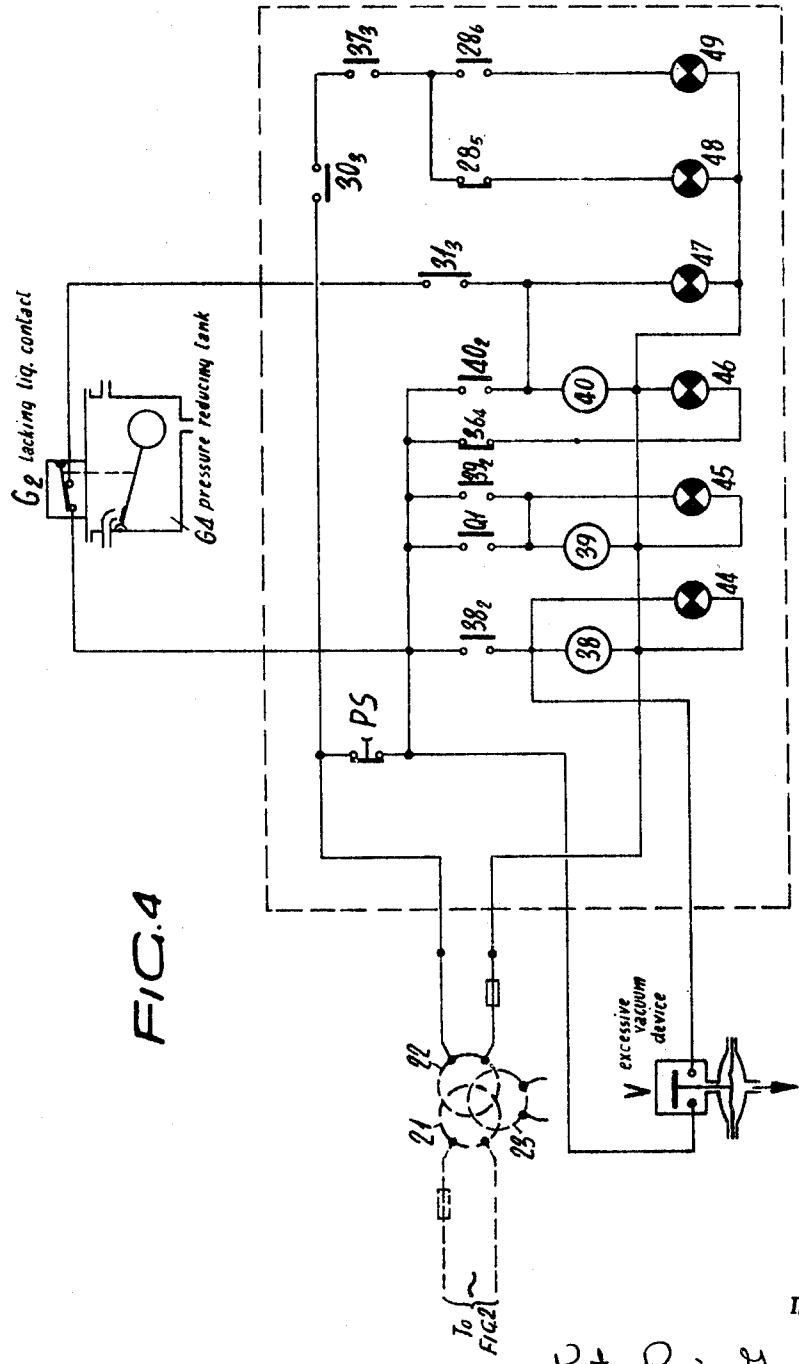

FIG.4

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March 31, 1970 P. RIVA ET AL 3,503,433
CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE
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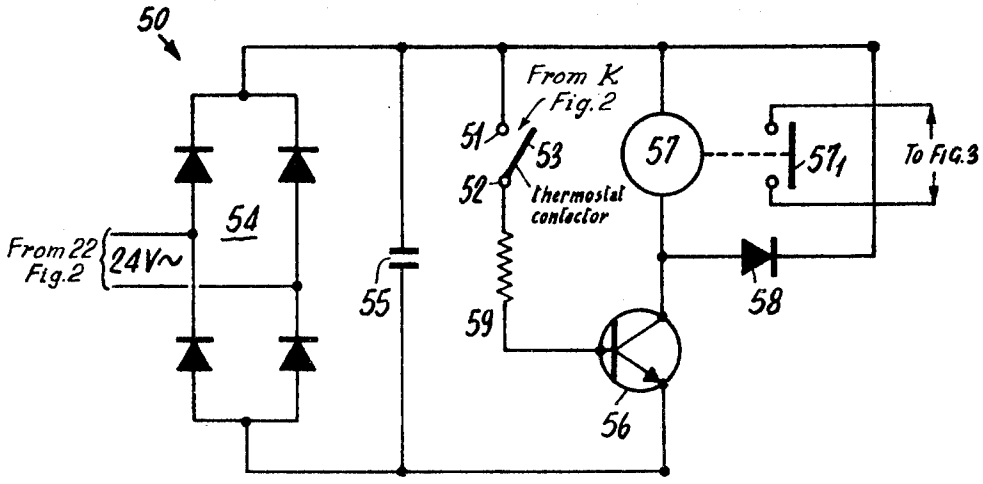

FIG. 5

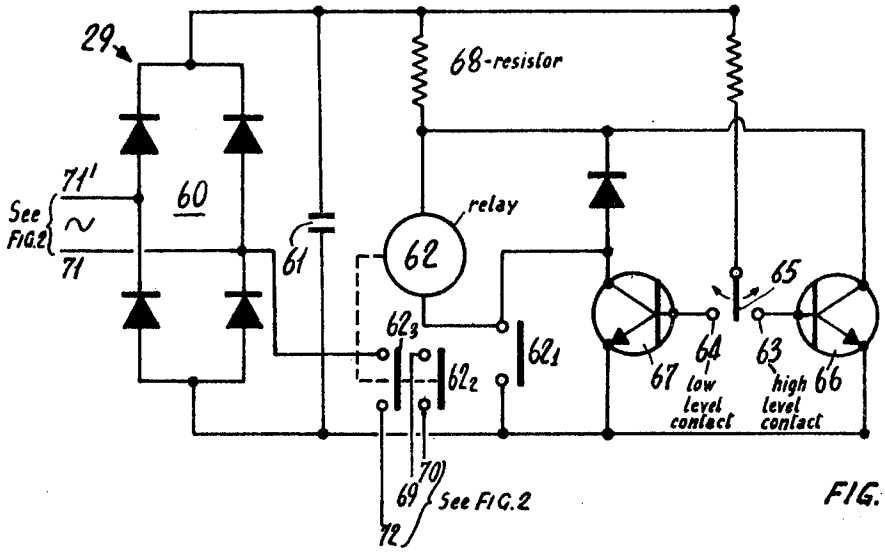

FIG. 6

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CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

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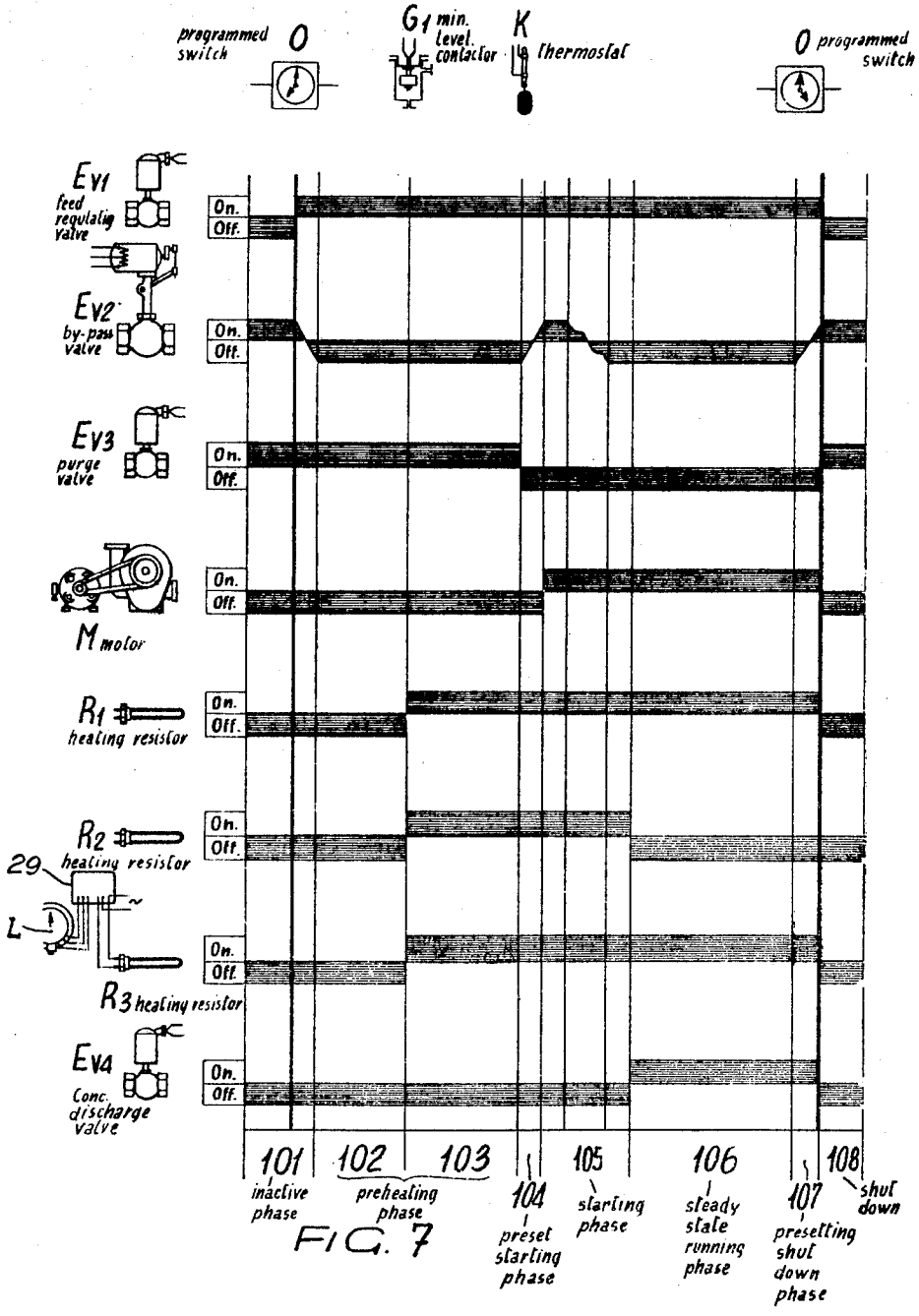

FIG. 7

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United States Patent Office

3,503,433

Patented Mar. 31, 1970

3,503,433

CONTROLLED RECOMPRESSION EVAPORATOR WITH REGULATED HEATING, FEED AND DISCHARGE

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Filed Sept. 7, 1966, Ser. No. 577,726
Claims priority, application Italy, Apr. 13, 1966, 16,746/66
Int. Cl. B01d *1/06, 1/28, 3/42*
U.S. Cl. 159—44
10 Claims

ABSTRACT OF THE DISCLOSURE

A completely automated mechanical thermo-compression evaporator for aqueous solutions which comprises a number of interrelated means to control the various phases of the evaporator via electrical control circuitry. The various means include means feeding an aqueous solution into the evaporator and for preheating same. Means for starting the compressor are provided and for running the evaporator under steady state conditions and thereafter for stopping same. The electrical control circuitry also functions to signal various abnormalities in the operation of the evaporator to shut it down.

The present invention relates to mechanical thermocompression evaporators for aqueous solutions.

Mechanical thermocompression evaporators are already known requiring, during running, the operator's assistance and supervision.

Mechanical thermocompression evaporators are also known, in which the supply of auxiliary heat during running is automatically adjusted and is moreover provided with devices which automatically close down the evaporator if the flow of feed liquid is accidentally interrupted, or if the vapour compressor is working below certain predetermined temperatures.

However, though an evaporator thus equipped assumes semi-automatic characteristics, the various delicate presetting operations for the pre-heating, running and stopping of the evaporator, have instead remained entrusted to the manual intervention and judgement of the operator.

The true distillation is normally preceded by a preheating and starting phase of the evaporator. Said phase which, as it will be seen later on, implies a succession of operations and has a duration varying from two to three hours.

This means that if the preheating and starting of the evaporator begin when the plant activity starts, the distillate production will only start after two or three hours with the result that, should the distillate be produced at the beginning of the factory activity, as required in almost all cases, it will be necessary for the operator appointed to the control of the evaporator, to intervene two or three hours before in order that he may carry out the aforesaid pre-heating and starting operations.

Similarly, very often plant schedules require that the evaporator should not be stopped at the ceasing of the normal plant activity, but that it should continue its output still for a further fixed period (night hours).

It is obvious that under these circumstances, the operator is obliged in both cases, to go to the factory before and after his working day in order to set at work and halt the evaporator, this thing clearly representing an inconvenience.

Among the other things, the starting phase which follows the pre-heating one, requires a certain technical competence from the operator who has been appointed to it.

Also for this reason, the automation of the evaporator has become an exigency specially felt by those industries having shortage or even lack of a qualified person to be appointed to the control of such a machine.

It is therefore an object of the present invention to overcome the above disadvantages.

Accordingly, the present invention comprises, in a suitable way for use with a mechanical thermocompression evaporator, an apparatus including means apt to automatically and successively control: the feeding of an aqueous solution inside the evaporator, pre-heating of the solution, setting out of the compressor, running of the evaporator under steady state conditions and its stopping as well as means responsive to possible abnormalities in the operating conditions of the evaporator, and shut it out at the same time.

Moreover, the invention also includes a mechanical thermocompression evaporator equipped with said apparatus.

In order to have the invention fully understood, one embodiment of it will now be described with reference to the here enclosed drawings, wherein:

FIG. 1 shows the hydraulic system of a mechanical thermocompression evaporator wherein the principal component parts and the elements controlled by the automation apparatus of the following figures, are represented;

FIG. 2 shows the electric system of the power circuit for the apparatus according to the present invention;

FIG. 3 shows the electric system of the control circuit for the apparatus according to the present invention;

FIG. 4 shows the electric system for the alarm and signal apparatus (Q.A.) that in FIG. 2 is represented in block;

FIG. 5 shows the relay electronic system for the thermostat shown in FIGURE 2;

FIG. 6 shows the relay electronic system for the vacuum gauge L represented in FIGURE 2;

FIG. 7 shows the programme cycle for the apparatus according to this invention.

Particular reference will now be made to FIGURE 1 of the drawings in which, as shown, the following have been indicated: a vapour tank A, a condenser-evaporator B, a heating chamber D, a distillate heat exchanger E, a concentrate heat exchanger H, a vapour compressor I, a suction piping N of the compressor, an automatic feeder G3 and a pressure reduction tank G4 for the liquid in question.

In the above mentioned hydraulic system of FIGURE 1, the members relating to the control automatic apparatus of the evaporator, are the following: a minimum level magnetic contact G1; a float contact G2 indicating the lack of the liquid fed; a group R1 of heating electric resistors energized both during the pre-heating and the steady state operation or working running of the evaporator; a group R2 of heating electrical resistors energized only in the pre-heating phase; a group R3 of heating electrical resistors energised directly in the preheating phase and switched into circuit with the automatic control device for the auxiliary heating during the steady state operation (we point out that, for simplicity of drawing, groups R1, R2 and R3 of electrical resistors have been schematically represented by a sole element in FIGURES 1 and 2 in the annexed drawings, however this must not be considered in a restrictive sense); a vacuum gauge L connected with said automation; a vacuum state value V to stop the evaporator in case of excessive vacuum; a motor M for driving the compressor; an inlet electrovalve EV1 for the liquid in question; a motorized valve EV2 in the vapour compressor by-pass; a compressor purge electrovalve EV3; a concentrate discharge

electrovalve EV4; a thermostat K with electrical contacts for maximum values related to the compression temperature.

The path of the fluid is clearly indicated with the arrows represented in FIGURE 1 and, moreover, the working of such hydraulic system will be explained below.

Now, with particular reference to FIGURES 2 to 6, we shall shortly describe the power and the control circuits, while, for a correct interpretation of said circuits, we suggest the reading of the drawings together with the detailed explanation of the working of said apparatus which will be given later on.

POWER CIRCUIT (FIGURE 2)

The power circuit substantially comprises the three-phase line RST, provided with a general switch **20**, which line feeds the primary winding **21** of a three-winding transformer whose secondary winding **22** feeds the alarm apparatus Q.A. (FIGURE 4) and whose secondary winding **23** feeds the control circuit shown in FIGURE 3.

The power circuit comprises, moreover, a working motor M of compressor I, this motor, being controlled through a contactor **24** (see FIGURE 3) whose main contacts 24_1, 24_2 and 24_3 (shown in FIGURE 2) are respectively connected with the three phases of motor M before the protective thermal relay Q; a group R1 of resistors connected with the three-phase branch line RS by means of main contacts 25_1 and 25_2 of a contactor **25** (shown in FIGURE 3); a group R2 of resistors connected with the three-phase branch line RT by contacts 26_1 and 26_2 of a contactor **26** (shown in FIGURE 3); and a group R_3 of resistances connected with the three-phase branch line ST by contacts 27_1 and 27_2 of a contactor **27** (shown in FIGURE 3) during the evaporator pre-heating phase, and by contacts 28_1 and 28_2 of a contactor **28** (shown in FIGURE 3) during the steady condition phase.

We point out that during the steady condition phase, group R3 of resistors is connected indirectly to the three-phase line by the electronic relay **29** shown in FIGURE 2 and represented in FIGURE 6 in detail, as it will be more clearly explained in the specification of the cited FIGURE 6. We insist again upon the fact that groups R1, R2 and R3 of resistors have been indicated in FIGURE 2 by a single resistor element for drawing evidence.

As it may be noted in FIGURE 2, both for motor M circuit and for heating resistors circuit R1, R2 and R3, a protection by means of common fuses has been realized.

CONTROL CIRCUIT

The control circuit, represented in FIGURE 3 in detail, is fed—through conductors **41** and **42**—by the secondary winding **23** of the three-phase transformer previously cited and shown in FIGURE 2.

The control circuit, whose function is to control the evaporator whole working cycle, as it will be explained later on, is represented as a functional diagram and is substantially formed by common electromagnetic relays shown with numbers **30** to **37** and by timers T1, T2 and T3 whose working will be described later on. Besides the aforesaid elements and contaactors **24** to **28**, the control circuit also comprises a particular cyclic relay **43** which is operated by timer T3, as represented in FIGURE 3 by a dash line, this cyclic relay being apt to successively close its four independent contacts, with a certain fixed program.

We do not describe in detail the control circuit represented in FIGURE 3, owing to the fact that a technician of the field is in a position to read such a functional diagram, while the direct reading of the drawing can be affected together with the reading of the working detailed explanation of the apparatus, in order to correctly understand the working of the control circuit itself.

ALARM CIRCUIT

In FIGURE 4 of the annexed drawings, it has been represented, in detail, the alarm circuit indicated in FIGURE 2 by Q.A.

As already stated, the alarm circuit is fed by the secondary winding **22** of the three-winding transformer and it substantially comprises common electromagnetic relays **38**, **39** and **40** and the alarm lamps **44** to **49** respectively for the excessive vacuum **44** overload of motor **45**, inactive system **46**, lack of water **47**, plant in the heating phase **48** and in the running phase **49** connected in the way clearly represented by FIGURE 4 itself.

Moreover the alarm circuit comprises the contacts connected with the vacuum state V and the float contact G2 of tank G4 for the reduction of the pressure of the unevaporated liquid.

Also for the alarm circuit of FIGURE 4 please refer to its description which will be made together with the detailed description of the apparatus.

FIGURE 5 illustrates the diagram of the electronic relay of thermostat K, which electronic relay has been represented in FIGURE 2 by block **50**.

As it appears from FIGURE 2, the electronic relay **50** is fed, with a 24V tension, by the secondary winding **22** of the three-winding transformer and is controlled by thermostat K which represents the two contacts **51** and **52** apt to be short circuited by the liquid of thermostat K.

In FIGURE 5 thermostat K has been represented under the form of a switch whose movable contact **53** has the function of the liquid of thermostat K.

As shown in FIGURE 5, the electronic relay **50** comprises a common rectifying circuit **54** with a smoothing capacitor which feeds, through a transistor **56**, an electromagnetic relay **57** whose function will be explained later on and whose auxiliary contact 57_1 is also represented in the functional diagram of FIGURE 3. In parallel with relay **57**, there is a diode **58** apt to protect transistor **56** from the reverse overvoltage.

In FIGURE 5, the transistor **56** has its collector connected to the coil of relay **57**, its emitter directly connected to one end of rectifier **54**, and its connecting base is connected to the other end of rectifier **54** through a resistor **59** and a movable contact **53** which contact **53** together with the fixed contacts **51** and **52** represent, in their whole, thermostat K of FIGURE 2.

The electronic relay has the function to protect the contacts **51**, **52**, **53** with which thermostat K is provided; in fact, said contacts could not absorb the exciting current of the coil of relay **57** and therefore it is advisable to amplify through transistor **56**, the small current which interests the thermostat contact as shown in the diagram of FIGURE 5, in order to have a current with a value sufficient to energize the relay **57**.

Now we are going to describe FIGURE 6 representing the electronic diagram of a second electronic relay indicated in FIGURE 2 with **29**, which is controlled by level meter or vacuum gauge L.

Also this circuit is a transistor common circuit, at whose input there are: a rectifier **60** connected through conductors **71** and **71'** to auxiliary contacts 28_2 and 28_1, respectively, of electromagnetic switch **28** a levelling capacitor **61** connected in parallel to the rectifier itself; and a relay **62** operated by level meter or vacuum gage L (FIGURE 2) which in FIGURE 6 has been represented with movable contact **65**, this latter contact being able to connect either with maximum value contact **63** or with minimum value contact **64**.

The maximum value contact **63** and minimum value contact **64** are respectively connected with the base of transistors **66** and **67** which are apt to amplify not only the current signal passing through the contacts of level meter L, but also to realize a memory in order to main-

tain relay **62** energized till when the maximum value contact **63** is closed.

More exactly the electronic relay of FIGURE 6 has the function of protecting the contacts of level meter **L**; besides, it must have relay **62** energized at the same moment in which contact **64** closes with contact **65** of the level meter L; keeping it excited also after that such a contact has been opened, while it will be only de-energized when contact **63** is closed with contact **65**.

In order to keep relay **62** energized also after the opening of the minimum value contact of level meter L, a holding contact 62_1 is utilized, as it is shown in FIGURE 6.

Instead, when the maximum value contact of level meter L is closed, transistor **66** is brought into conduction state and therefore the ends of the coils of relay **62** are practically short-circuited in such a way that, since there is no more tension on the coil of the relay **62**, this latter one de-energizes.

We point out that such short-circuit cannot cause any damage to the apparatus because the current is limited by a high resistor **68** in series with relay **62** itself.

Moreover in FIGURE 6 it has been represented the auxiliary contact 62_2 of relay **62** in order to connect conductors **69** and **70** of FIGURE 2 and an auxiliary contact 62_3, this latter connecting the conductors **71** and **72** of FIGURE 2, in consequence of the energizing of relay **62**.

In the diagram of FIGURE 7, the programming cycle is shown in the sequence of the phases following one another automatically during the working of the previously described apparatus. The various phases have been indicated with numerical references from **101** to **108** arranged according to a horizontal axis, while, according to a vertical axis, we have indicated the symbols of the various elements which are set in action during the evaporator cycle; more exactly we have indicated with "ON" the energized condition for each element and with "OFF" their de-energized condition.

To better understand the working of the evaporator, we shall summarize, hereunder, the various situations of elements in the single phases and, afterwards, we shall explain the detailed working of the apparatus.

Phases of inactivity of the evaporator (**101**)

EV1—de-energized and closed
EV2—de-energized and open
EV3—de-energized and open
M—stationary
R1—off
R2—off
R3—off
EV4—de-energized and closed

Pre-setting of the pre-heating (**102**)

O—electrical switch of appropriate pre-set programming gives a start to said cycle closing contact O_1 (FIGURE 3). More precisely:
EV1—is energized and opened allowing the entrance into the evaporator of the unevaporated liquid in question
EV2—is energized and closed
EV3—is de-energized and remains open
M—stationary
R1—off
R2—off
R3—off
EV4—de-energized and closed

When the unevaporated liquid in question reaches such a level as to have covered the heating resistances, the pre-heating phase takes place by means of G1.

Pre-heating phase (**103**)

EV1—energizes and remains open
EV2—de-energized and remains closed
EV3—de-energized and open
M—stationary
R1—on
R2—on
R3—on (directly)
EV4—de-energized and closed

When the vapour compressor I has reached the work temperature indicated by the maximum electrical control of the thermometer K, the pre-set starting phase takes place.

Pre-set starting phase (**104**)

EV1—energizes and remains open
EV2—self-energizing, it opens
EV3—self-energizing, it closes
M—stationary
R1—on
R2—on
R3—on (directly)
EV4—de-energized and closed

Starting phase (**105**)

When EV2 is completely open:

EV1—is still energized and open
EV2—de-energized and open
EV3—is energized and closed
M—begins running and operates the compressor
R1—on
R2—on
R3—on (directly)
EV4—de-energized and closed

The evaporator remains for a certain time in the above described conditions and then begins the intermittent closure of the valve EV2.

On the complete closure of EV2, and after a certain predetermined interval, the running phase (**106**) begins.

Steady state running phase (**106**)

EV1—still energized and open
EV2—de-energized and closed
EV3—energized and closed
M—running
R1—on (auxiliary steady state heat)
R2—is off
R3—is switched into circuit with the automatic vacuum regulation apparatus (**29**)
EV4—energized and open

The steady state running phase is prolonged up to the time per-set on the clock of the switch O;

On opening the contract of electric switch O the next phase (**107**) is commenced.

Pre-setting of stopping (**107**)

In this phase, the opening of EV2 is started while the other members remain in the position of the running phase (**106**).

Stopping (**108**)

When EV2 is completely open, the following takes place:

EV1—de-energized and closes the flow of feed liquid
EV2—de-energized and remains open
EV3—de-energizes and opens
M—stops
R1—cuts out
R2—remains off
R3—cuts out
EV4—de-energizes and closes

The detailed functioning of the apparatus above described is more fully described below.

Pre-setting of the pre-heating phase

On the closure of the contact O_1 (FIGURE 2) of the programmed switch O, the auxiliary relay **36** and successively the relay **30** are energized.

The relay 30 thus energized, closes its self-feeding contact 30_1 and closes another of its contacts 30_2, permitting opening of the electrovalve EV1, and at the same time puts the servomotor of the by-pass valve EV2 into action.

The energization of EV2 takes place, provided that the relay 33 (having rest contact 33) which is under the control of the thermometer K, be de-energized. In fact, relay 33 is controlled by contact 57 of relay 57, (see FIGURES 3 and 5) which energizes at the closure of contact 53 (FIGURE 5).

The energization follows of relay 37 which gives voltage to the remaining portion of the control circuit (make contacts 37_1 and 37_2).

The energization of the relay happens only when the unevaporated liquid of the evaporator reaches G1 which excites, in its turn, relay 31 (make contact 31_1) but it is necessary that no intervention conditions for the alarms exist.

More precisely it is necessary that the following be de-energized (see FIGURES 4):

(a) the relay 38—of the excessive vacuum alarm-rest contact 38_1
(b) the relay 39—of the overloading motor alarm-rest contact 39_1
(c) the relay 40—of the lack of feed liquid alarm-rest contact 40_1.

Pre-heating phase

The following contactors are simultaneously energized:

25—energizing the group of heating resistors R1
26—energizing the group of resistors R2
27—energizing the group of resistors R3.

The contactors 26 and 27 come into action because the relay 35 is in a de-energized position (rest contact 35_3).

At this moment the unevaporated liquid contained in the evaporator is heated up to boiling.

The vapour that develops is gathered in the tank A, and EV2 being closed in advance, the vapour itself is obliged to run, through the piping N, into the compressor I and heat it.

When the fluid of the thermometer K connects contacts 51, 52 (the contact 53 is closed, see FIGURE 5) the relative relay 57 is energized which relay by means of its contact 57_1 energizes the relay 33.

The contact 33_2 of the relay 33 makes the by-pass valve EV2 open by means of its servomotor and at the same time, by means of the contact 33_1, prevents the possibility of re-closure of EV2.

Starting phase

When EV2 is completely open, the limit contact FC_1 closes and the auxiliary relay 32 is energized.

A contact 32_1 of said relay puts the motor M into motion by means of the contactor 24, provided that the relay 33 is energized (make contact 33_3).

Simultaneously, on account of the fact that the relay 34 is de-energized, the control is given to the time lag device T1, whose contact $T1_1$ closing after a predetermined time, can energize the relay 34, whose contact 34_1 takes the feed away from the time lag device T1.

Another contact of the relay 34, that is the contact 34_2, gives the control to the cyclic interrupter T3-43, which makes the electro-valve EV2 close with a cycle of fixed intermittence.

A third auxiliary contact 34_5 does not allow a rapid opening of EV2.

When the by-pass EV2 is again completely closed, the limit contact FC2 is closed.

The limit contact FC2, gives the control to the time lag device T2, provided that 24 is energized and 35 de-energized (make contact 24_1 and rest contact 35_4). The device T2, after a predetermined time, closes its contact $T2_1$ and the relay 35 is energized, its contacts operating as follows:

The make contact 35_1 self-feeds the relay itself.

The make-contact 35_2 energizes the concentrate discharge electrovalve EV4 and also the contact 28, which switches by means of contacts 28 and 28_2 the group R3 of resistors into circuit with the electronic relay 29 for the vacuum regulation control.

Rest contact 35_3 de-energizes the contactors 26 and 27 cutting out the resistor group H2, by means of make contacts 26_1 and 26_2 and the direct feed of the resistor group R3 with the make contacts 27_1 and 27_2. The rest contact 35_4 de-energizes the device T2. At this point, the evaporator is in the steady state running condition.

Pre-setting for the stopping

When the programmed switch O indicates the predetermined stop time, it opens its contact O_1 and consequently it de-energizes the relay 36 which, through its auxiliary rest contact 36_1 gives the opening command to the by-pass valve EV2.

The contacts 15/2 and 15/3 simultaneously prevent the closure of EV2.

Simultaneously, the make contacts 36_2 and 36_3 hinder the closing of EV2.

From the instant that O_1 opens, the relay 30 remains energized in consequence of its self-feeding 30_1 till the valve EV2 is completely open.

This condition of the relay 30 is possible because the limit contact FC1 excites the relay 32, which in its turn opens the relative rest contact 32_2 taking the feed from the relay 30 itself.

Stopping

With the stopping of the feed to 30, the contact 30_2 is opened, which provokes the interruption of the whole control circuit.

As a consequence of this, the following takes place:

the electrovalve EV1 de-energizing, closes
the electrovalve EV2 remains in the open position
the electrovalve EV3 de-energizing, opens
the contactor 24 de-energizes and stops the motor M and compressor I
the contactor 25 of the group of resistors R1 is de-energized
the contactor 26 of the group of resistors R2 is de-energized
the contactor 28 for the group of resistors R3, switched into circuit with the automatic vacuum regulation apparatus 43, is de-energized
the electrovalve EV4, de-energizing, closes.

ANOMALIES IN RUNNING

(a) if during running, a condition of excess vacuum in the evaporator arises, the contact of the vacuum state device V energizes the relay 38 (FIGURE 4) which, by means of its contact 38, de-energizes the relay 37 of the general panel. The relative contacts 37_1 and 37_2, opening interrupt the feed to the control circuit, stopping the evaporator. In the meantime, 38, closes its contact 38_2 which makes the signal lamp 53 light, indicating the cause of stopping of the evaporator due to excessive vacuum;

(b) if, during running, for any reasons, the vapour compressor overloads the motor M which operates it, the thermal protection relays Q of the contactor 24 intervene. The action of Q closes contact Q_1 and relay 39 is energized, which relay 39, by means of the auxiliary contact 39_1 opens the relay 37 thereby taking away the voltage from the evaporator control circuit. Simultaneously the relay 39 closes its contact 39_2 and the signal lamp 45, which indicates stopping of the evaporator because of overloading of the motor M of the compressor I, is simultaneously lit;

(c) if during running, the flow of unevaporated liquid in question should accidentally come to a stop, the float contact G2 closes, exciting the relay 40.

This, by means of its contact 40_1 de-energizes **37** thus taking away the voltage from the control circuit. The evaporator stops working and lights the relative lamp **47** indicating stoppage because of lack of feed liquid. On the basis of the light signals, the operator knows the cause of the evaporator stoppage and obviously makes provision to eliminate it.

Before putting the evaporator back into service, however, he must push the push button of the alarm cancel device P.S.

Operating in this way he takes the cycle back to the programming starting position.

As stated above, it is also an object of the present invention to provide a mechanical thermocompression evaporator incorporating the above described apparatus.

Variations may be brought to the apparatus object of the present invention without, for that, going beyond the protective field of the invention itself.

In particular, instead of electric resistors for pre-heating and heating under steady state conditions of the unevaporated liquid, coils may be used inside which low-pressure vapour flows, whose flux is controlled by electrovalves connected with the same organs controlling, in the above described form of execution, the insertion of the resistors.

Description of the working of the apparatus

By the programmed switch O, the evaporator working period is established by fixing the starting and end hour of the working cycle which comprises the phases indicated by reference numbers **102** to **107** in FIGURE 7.

When contact **1** of the programmed switch O closes (FIGURE 3), relay **36** is energized, which relay sets into work its own auxiliary contacts, of which:

36_1 disconnects the opening circuit of valve EV_2;
36_2 closes the closing circuit of valve EV_2;
36_3 pre-sets the insertion of the cyclic relay **43**;
36_4 (FIGURE 4) determines the switching-off of the lamp **46** signalling the evaporator inactivity;
36_5 determines the energization of relay **30**, which closes its self-feeding contact 30_1 and its contact 30_2 for energizing the closing circuit of valve EV_2;

at the same time, the auxiliary contact 30_3 (FIGURE 4) pre-sets the lighting of the signal lamps **48** and **49**.

Therefore the valve EV2 closes and the evaporator pre-heating phase takes place. At the same time that EV2 closes, valve EV1 opens, this latter valve allowing the flow of the liquid to treat.

The liquid starts flowing into the heating exchangers E and H, then it rises to the heating chamber D, successively entering the condensator-evaporator B till reaching the level fixed by G3. One moment before the water reaches said level, the minimum level magnetic contact G1 (FIGURE 1) is set in work, said contact G1 (FIGURE 1) inserting relay **31** (FIGURE 3) which, in its turn closes the self-feeding contact 31_1, it closes contact 31_2 which makes relay **37** energize, while contact 31_3 (FIG. 4) closes to pre-set the lamp **47** insertion when the liquid to be treated in G4 lacks.

The energization of relay **37** causes the closing of auxiliary contacts 37_1 and 37_2 which supply voltage to the remaining portion of the circuit of FIGURE 3 finding itself on the right of said contacts. At the same time, also contact 37_3 determining the switching on of lamp **48**, closes.

By closing contacts 37_1 and 37_2 the feeding of the remaining part of the circuit of FIGURE 3 causes the energization of contactors **25**, **26** and **27**, said contactors closing the respective contacts 25_1, 25_2; 26_1, 26_2 and 27_1, 27_2 (FIGURE 2), these latter directly inserting the heating elements R1, R2 and R3, supposing that the main switch **20** be closed. During the preheating phase—EV2 being closed—the vapor produced passes all through a vapor compressor to heat this latter and pre-set it to working. The pre-heating phase lasts until a temperature fixed by thermostat K is reached. When said temperature is reached, thermostat K closes its contacts **51**, **52** (FIGURE 2), i.e. with reference to FIGURE 5, the movable contact **53** connects the fixed contacts **51** and **52**, and, through the electronic relay **50**, it causes the energization of the electro-magnetic relay **57** (FIGURE 5), which closes its own contact 57_1 (FIGURES 3 and 5) and this latter causes, in its turn, the energization of relay **33**. The energization of relay **33** causes the opening of contact 33_1 of the closing circuit of EV2 and, at the same time, the closing of contact 33_2 of the opening circuit of EV_2; simultaneously also contact 33_3 closes, said contact pre-setting the circuit of FIGURE 3 for the energization of **24**, T1 and **34** and at the same time it determines the closing of EV_3. The opening of EV_2 causes the closing of limit contact FC_1 and the opening of limit contact FC_2. The phase **105** starts with the opening of EV2. The closing of FCI causes the energization of relay **32** whose auxiliary contact 32_1 determines the feeding of contactor **24** which closes its contacts 24_1, 24_2 and 24_3 (FIG. 2) for feeding motor M, and then the working of compressor I (FIGURE 2) that simultaneously—through the auxiliary contact 24_5 (FIG. 3)—determines the energization of timer T1. After a prefixed period of time, timer T1 closes its contact $T1_1$ which energizes the relay **34** which, with its own contact 34_1 de-energizes T1, while contact 34_2 sets in motion the timer T3 which drives the cyclic relay **43** for a closing at programmed intervals of valve EV_2 to gradually bring compressor I to its steady state conditions.

The contactor **24** energization determines; moreover, the closing of contact 24_4 which pre-sets timer T2 for the start when contact FC_2 is closed by the closing of valve EV_2. Now we are passing to the steady state conditions. Similarly we have the closing of contact 24_5 for the self-energization of both contactor **24** and relay **34** previously energized at closing of contact $T1_1$. Timer T2 is then set in motion and after a certain period of time it closes its contact $T2_1$ which determines the energization of relay **35** which is self-energized with 35_1 and which, by the auxiliary contact 35_2 causes the energization and the opening of valve EV_4 for the discharge of the concentrate and the energization of contactor **28** which, with its own contacts 28_1 and 28_2 (FIGURE 2) switches the heating element R3 on the electronic relay **29** controlled by the vacuum gauge L for the auxiliary heating during the phase of steady state conditions. At the same time the auxiliary contact 35_3 opens, and contactors **26** and **27**, which disconnect elements R2 and R3, de-energize; the auxiliary contact 28_5 (FIG. 4) makes lamp **48** switch off and the auxiliary contact 28_6 makes lamp **49** switch on in FIGURE 4. At this point, we enter the phase of steady state conditions. During the steady state conditions, there may be the auxiliary heating of the heating element R3 controlled by the vacuum gauge L through the electronic relay **29**.

During the steady state conditions of the evaporator, the distillation of the liquid to be treated takes place. At the fixed hour of the stopping, the programmed switch O opens its contact O_1 de-energizing the relay **36** (FIG. 3) which causes the opening of valve EV2. When EV2 opens, also contact FC2 opens and there is the closing of contact FC1 which energizes the relay **32** whose auxiliary contact 32_2 opens and causes the de-energization of relay **30** which opens its auxiliary contact 30_2 taking off the feeding to the whole circuit and consequently the evaporator stops working. The evaporator remains in the rest position for the whole fixed period and the successive day, at the fixed hour, the switch O closes its contact O_1 again making the evaporator start a new working cycle.

What is claimed is:

1. An apparatus for the complete automation of a mechanical thermocompression evaporator comprising in combination:

(a) an electrical motor for operating the evaporator compressor, which is connected with a suitable power source;

(b) a first immersion heating means of the aqueous solution to be treated directly inserted in either phase of the pre-heating and running-under-steady-state conditions of the evaporator; a second immersion heating means of the said aqueous solution energized directly during the pre-heating phase of the evaporator; and a third immersion heating means of the said aqueous solution, directly energized during the preheating phase of the evaporator, and indirectly energized through an automatic controlling device for auxiliary heating during the running of the evaporator under steady state conditions;

(c) an electric circuit for automatically controlling various working phases of the evaporator, said circuit having a first, electro-valve for controlling the flow of aqueous feed solution to be treated in the evaporator; a programmed switch whose closing controls the energization and opening of the first mentioned electrovalve, in order to start the evaporator working cycle;

a second compressor by pass electro-valve; means to control the energization and closing of the second compressor by pass electrovalve depending on the evaporator temperature, during the pre-heating phase; means adapted to set the said compressor motor in motion during the starting phase; and a number of timer means acting in sequence and adapted to control a cyclic switch in order to determine the cyclic closing and opening of the second mentioned electrovalve, according to an already fixed sequence, during said starting phase;

a third compressor dump electro-valve; means adapted to energize and close the third electrovalve during the evaporator pre-setting of starting and pre-setting of stopping phases;

a fourth valve for the discharge of the concentrate; means adapted to energize and keep the fourth cited electro-valve opening during the working-under-the-steady-state conditions for the discharge of the concentrate itself; the control circuit also comprising: means controlling the direct insertion of the three said heating means during the pre-heating phase as a function of the minimum allowed level of fluid in the evaporator; means adapted to connect the third, said heating means on the automatic control device of the auxiliary heating and to disconnect the second heating means during the working phase under steady state conditions, the said programmed switch causing the evaporator working cycle to start and stop in fixed periods;

(d) said apparatus, moreover, comprising safety means adapted to signal abnormal stops and running anomalies of the compressor, simultaneously stopping the working of the compressor itself.

2. An apparatus according to claim **1**, characterized in that said first, second and third heating means are electric resistors.

3. An apparatus according to claim **1** characterized in that said first second and third heating means, are pipe coils inside which low pressure vapour flows.

4. An apparatus according to claim **1**, characterized in that the automatic control device of the auxiliary heating comprises a contact vacuum gauge connected with the dome of the evaporator and is provided with minimum and maximum value contacts to operate an electronic relay which indirectly connects and disconnects the said third heating means as a function of the vacuum reached in the dome of the evaporator itself.

5. An apparatus according to claim **1**, characterized in that said means for the control of the energization and closing of the second electro-valve as a function of the temperature and level of the fluid reached in the evaporator during the pre-heating phase, comprise a minimum level magnetic contact connected with a float directly operated to the aqueous solution to be treated, and a first auxiliary contact of a relay operated by the closing of electric contacts of a contact thermostat sensing the compressor temperature, the closing of the last relay also allowing the energization of further relay means adapted to control the connection of the said heating means.

6. An apparatus according to claim **1**, characterized in that the timer means are adapted to control the cyclic opening of the said second electro-valve during the starting phase and comprises a first timer which, when closing its contact after a fixed time, energizes a relay which, in its turn, operates the said timer of the cyclic switch thus effecting the closing of the second electro-valve with the fixed intermittance cycle.

7. An apparatus according to claim **1**, characterized in that the means adapted to connect the third heating means on the automatic control device of the auxiliary heating and to disconnect the said second heating means during the phase under steady state conditions, comprise relay means controlled by a further timer operated by an off-limit contact at the closing of the second electro-valve and after that this latter one has effected the fixed intermittance cycle, the last cited timer causing, moreover, the opening of the previously cited fourth valve.

8. An apparatus according to claim **1**, characterized in that it comprises a first safety means adapted to signal an excessive vacuum inside the dome of the evaporator, the said safety means being constituted of a vacuum state inserted in the said dome, this vacuum state acting on a relay whose operation depends on the vacuum state itself, to break the energizing and stop the running of the evaporator, said vacuum state causing also the lighting of a corresponding signalling lamp.

9. An apparatus according to claim **1**, characterized in that it comprises a second safety means adapted to signal a motor overload, substantially constituted by a thermic relay inserted on the energizing phases of the motor, to break the energizing itself, said thermic relay causing—through an auxiliary contact—the energizing of a further relay which acts to deenergize the control circuit and to stop the evaporator, lighting, at the same time, a signalling lamp.

10. An apparatus according to claim **1**, characterized in that it comprises a third safety means adapted to signal, during the run under the steady state conditions, the lack of the fluid to treat, said third safety means comprising a contact operated by a float placed on the tank for the reduction of the evaporator pressure, the closing of said contact causing the energization of a further relay which deenergizes the cited control circuit thus stopping the evaporator and lighting, at the same time, a signalling lamp.

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