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FORM 1  
REGULATION 9

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-1973

APPLICATION FOR A PATENT

I/We McNEILAB, INC.

of Spring House, PENNSYLVANIA, U.S.A.

hereby apply for the grant of a Patent for an invention  
entitled:

LIGHT ARRAY ASSEMBLY FOR PHOTOACTIVATION  
PATIENT TREATMENT SYSTEM

which is described in the accompanying complete specification.  
This Application is a Convention Application and is based on  
the Application(s) numbered: 834,256 for a Patent or similar  
protection made in U.S.A. on 27 February 1986.

My/Our address for service is:

GRIFFITH HASSEL & FRAZER  
71 YORK STREET  
SYDNEY N.S.W. 2000  
AUSTRALIA

DATED this 26th day of February, 1987.

McNEILAB, INC.

By his/their Patent Attorneys

GRIFFITH HASSEL & FRAZER

TO: THE COMMISSIONER OF PATENTS  
COMMONWEALTH OF AUSTRALIA

3787A:rk

APPLICATION ACCEPTED AND AMENDMENTS

APPROVED

4 - 5 - 90

JCG

B — APPLICATION BY ASSIGNEE OF INVENTOR

COMMONWEALTH OF AUSTRALIA  
PATENTS ACT 1952

DECLARATION IN SUPPORT OF AN APPLICATION FOR A PATENT

(Name of applicant)

In support of an application made by: ... MCNEILAB, INC. ....

(Title)

for a patent for an invention entitled: LIGHT ARPAY ASSEMBLY FOR PHOTO-ACTIVATION PATIENT TREATMENT SYSTEM

(Full name and address of signatory)

I, David J. Levy .....  
of McNeilab, Inc. ....  
Spring House, PENNSYLVANIA, U.S.A. ....

do solemnly and sincerely declare as follows:

(Full name and address of inventor(s))

- I am authorised by the above mentioned applicant for the patent to make this declaration on its behalf.
- The name and address of each actual inventor of the invention is as follows: Vernon H. Troutner and Martin J. King .....  
of 6221 58th Avenue North, St. Petersburg, FL 33709, U.S.A. ....  
and 12400 91st Avenue North, Seminole, FL 33542, U.S.A., .....  
respectively .....

(State whether by assignment or contract of employment)

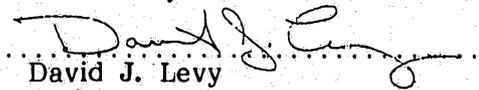
and the facts upon which the applicant is entitled to make this application are as follows: The applicant is the assignee of the .....  
said invention from the said inventors .....

(Delete paragraphs 3 and 4 for non-Convention application)

- The basic application(s) as defined by Section 141 of the Act was (were) made as follows:  
Country ... USA ..... on February 27, 1986 .....  
in the name(s) Vernon H. Troutner and Martin J. King. ....  
and in ..... on .....  
in the name(s) .....  
and in ..... on .....  
in the name(s) .....
- The basic application(s) referred to in the preceding paragraph was(were) the first application(s) made in a Convention country in respect of the invention the subject of this application.

(Place and date of signing)

Declared at New Brunswick, NJ this 22<sup>nd</sup> day of January 19 87

Signed:  .....  
David J. Levy  
Position: Assistant Secretary .....

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**(12) PATENT ABRIDGMENT (11) Document No. AU-B-69503/87**  
**(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 599357**

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- (54) Title  
**LIGHT ARRAY ASSEMBLY FOR PHOTOACTIVATION PATIENT TREATMENT SYSTEM**
- International Patent Classification(s)  
(51)<sup>4</sup> **A61M 001/36**
- (21) Application No. : **69503/87** (22) Application Date : **26.02.87**
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- (31) Number (32) Date (33) Country  
**834256 27.02.86 US UNITED STATES OF AMERICA**
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- (71) Applicant(s)  
**MCNEILAB, INC.**
- (72) Inventor(s)  
**VERNON H. TROUTNER; MARTIN J. KING**
- (74) Attorney or Agent  
**GRIFFITH HACK & CO. SYDNEY**
- (56) Prior Art Documents  
**US 4464166**  
**EP 138489**  
**US 4398906**
- (57) Claim

1. A light array assembly for use in a patient treatment system for altering cells including treating the cells with a photoactivatable agent and irradiating said cells and said agent whereby said agent is caused to be activated and to affect said cells, said agent and said cells during irradiation being contained in an irradiation chamber, comprising a top printed circuit board and a bottom printed circuit board having mounted therebetween a plurality of radiation sources for providing photoactivating illumination, said printed circuit boards having a plurality of contacts adapted to receive electrical power for energizing said radiation sources.

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PATENTS ACT 1952

Form 10

COMPLETE SPECIFICATION

FOR OFFICE USE

Short Title:

Int. Cl.:

Application Number: 69503/87  
Lodged:

Complete Specification-Lodged:

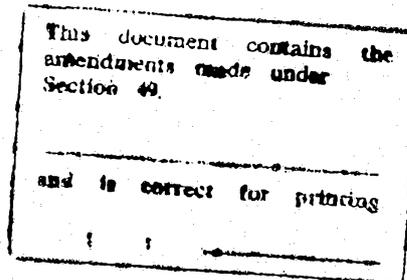
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Priority:

Related Art:



TO BE COMPLETED BY APPLICANT

Name of Applicant: McNEILAB, INC.  
Address of Applicant: Spring House, PENNSYLVANIA, U.S.A.  
Actual Inventor: Vernon H. Troutner and Martin J. King  
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Complete Specification for the invention entitled:

LIGHT ARRAY ASSEMBLY FOR PHOTOACTIVATION  
PATIENT TREATMENT SYSTEM

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

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10 This invention relates to the field of treating cells with  
photoactivatable compounds and radiation which activates  
the compound thereby affecting the cells and specifically,  
relates to clinically useful systems for the  
extracorporeal treatment of blood cells, especially  
15 leukocytes, including a disposable source of U.V.  
radiation in a removable light array assembly.

Background of the Invention

20 It is well-known that a number of human disease states may  
be characterized by the overproduction of certain types of  
leukocytes, including lymphocytes, in comparison to other  
populations of cells which normally comprise whole blood.  
Excessive or abnormal lymphocyte populations result in  
25 numerous adverse effects to patients including the  
functional impairment of bodily organs, leukocyte mediated  
autoimmune diseases and leukemia related disorders many of  
which often ultimately result in fatality.

30 U.S. Patent Nos. 4,321,919; 4,398,906; 4,428,744; and  
4,464,166 to Edelson describe methods for treating blood  
whereby the operation or viability of certain cellular  
populations may be moderated thereby providing relief for  
these patients. In general, the methods comprise treating  
35 the blood with a dissolved photoactivatable drug, such as

psoralen, which is capable of forming photoadducts with DNA in the presence of U.V. radiation. It is believed that covalent bonding results between the psoralen and the lymphocyte nucleic acid thereby effecting metabolic inhibition of the thusly treated cells. Following extracorporeal radiation, the cells are returned to the patient where they are thought to be cleared by natural processes but at an accelerated pace believed attributable to disruption of membrane integrity, alteration of DNA within the cell, or the like conditions often associated with substantial loss of cellular effectiveness or viability.

Although a number of photoactivatable compounds in the psoralen class are known, 8-methoxy psoralen is presently the compound of choice. An effective radiation for this compound, and many psoralens in general, is the ultraviolet spectrum in the range of approximately 320 to 400 nanometers, alternatively referred to as the U.V.A. spectrum. As the development of photoactivatable compounds proceeds, it may be expected that changes in the preferred activation radiation spectrum will be necessary. Suitable selection of radiation sources will, of course, increase treatment efficiency and is contemplated as an obvious optimization procedure for use with the inventions disclosed herein.

Although Edelson's methods have been experimentally shown to provide great relief to patients suffering from leukocyte mediated diseases, numerous practical problems require solutions. In particular, Edelson fails to provide a suitable apparatus for applying radiation to the cells, e.g. via a treatment station, in an economical and efficacious manner, or a system for incorporating a

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treatment station providing for the treatment of a patient in a clinically acceptable format.

Conventional techniques for photoactivating compounds associated with cells have relied on a plurality of devices including flasks, filtration columns, spectrophotometer cuvettes, and petri dishes. The sample to be irradiated is added to the containers and the container placed adjacent to the radiation source. Such systems tend to be laboratory curiosities as they fail to provide the necessary safeguards intrinsically necessary where patient bodily fluids are concerned, particularly since these fluids must be returned to the patient thereby necessitating strict avoidance of contamination. Further, such methods tend to be volume limited, are characterized by many mechanical manipulations and are generally unacceptable from a clinical and regulatory viewpoint. It is an object of the present invention to provide methods, and apparatus suitable for use with the Edelson methods to overcome the limitations associated with the conventional expedients.

Australian Patent No. 566,710 describes a practical device for coupling the radiation provided by commercially available light sources, such as the so-called "black-light" fluorescent tubes, to cells for treatment by Edelson's photoactivated drug methods. In summary, the disposable cassette described therein comprises a plurality of fluorescent tube-like light sources such as the U.V.A. emitting Sylvania F8TS/BLB bulb, which are individually, coaxially mounted in tubes of larger diameter which are, in turn, coaxially mounted in sealing arrangement within second outer tubes of even larger diameter thereby forming a structure having two generally

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elongated, cylindrical cavities about each radiation source. The inner cavity preferably communicates with the atmosphere thereby facilitating cooling of the radiation source. The second tube forming the outer cavity further  
5 comprises inlet and outlet means for receiving and discharging, respectively, the cells to be irradiated. A plurality of these structures are "ganged" and suitable connections made between inlets and outlets of adjacent members to provide for serpentine flow of cells through  
10 each outer cavity. Thus, continuous flow of the cells through the plurality of cavities surrounding the centrally disposed radiation sources facilitates thorough treatment of the cells. Additional, detailed description of the device may be obtained by direct reference to  
15 Australian Patent No. 566,710.

To be fully practical, the Taylor device requires a clinically acceptable instrument to house the device and to provide the cells to be treated in an appropriate form.  
20 Such an instrument is the object of the inventions described in U.S. Patent Nos 4,573,960, 4,568,328, 4,578,056, 4,573,961, 4,596,547, 4,623,328, and 4,573,962, fully incorporated herein by reference. While the instruments described therein work well, it is an object  
25 of the instant application to describe improved systems capable of implementing, in advanced fashion, the medical treatment principles first taught by Edelson.

It is another object of the present invention to provide  
30 still further improvements in greater patient safety and comfort while reducing treatment time and cost, by utilizing a newly designed disposable irradiation chamber. described more fully in U.S. Patent 4,737,140, (JJC-14), fully incorporated herein by reference, in an

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appropriate instrument which incorporates a new, advanced photoactivating light array assembly.

5 It is yet another object to provide an improved instrument which meets the above criteria while maintaining the positive attributes of the prior system; compactness, mobility, completeness, fully automated and monitored, coupled with ease of operation.

10 It is a further related object of this invention to provide, in contrast to the time consuming batch like processing of the prior system, disposable light array assembly for use with a continuous on-line patient treatment system wherein collection, separation, and cell  
15 treatment occur simultaneously, thereby reducing treatment time and increasing patient safety and comfort.

Brief Description of the Drawings

20 These and still other objects of the invention will become apparent upon study of the accompanying drawings wherein:

Figure 1 illustrates a preferred configuration of the system during collection, separation, and treatment;

25

Figure 2 shows a front elevational view of the flat plate irradiation chamber mating with a recirculation pump; and UVA light source array; and

30 Figure 3 shows a bottom view of the preferred embodiment of the light array assembly with the irradiation chamber mounted therein;

35 Figure 4 shows a perspective view of the light array assembly of the present invention.

Figure 5 is an exploded perspective view of the light array and the irradiation chambers.

5

In accordance with the principles and objects of the present invention there is provided a disposable light array assembly for use with a patient treatment apparatus for "on-line" extracorporeally photoactivating a photoactivatable reagent in contact with blood cells by collecting and separating on a continuous basis, blood from a patient while the patient is connected to the apparatus, returning to the patient undesired blood portions obtained during separation while the desired portion is photoactivatably treated and thereafter returning the thusly treated cells to the patient. As a result of this novel approach, the treatment system of the instant inventions optimizes and minimizes treatment time by concurrently conducting various aspects of such photoactivation treatment which were previously performed sequentially.

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More specifically, the apparatus collects and separates blood on a continuous basis as it is withdrawn from the patient and returns unwanted portions to the patient while concurrently energizing the irradiation sources in the disposable light array assembly for photoactivating the photoactivatable reagent in contact with the desired blood portion. Following photoactivation, the treated cells may then be facilely returned to the patient utilizing a drip chamber gravity feed infusion line incorporated in a dedicated tubing set.

25

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The light array assembly of the instant invention provides for efficient activation of photoactivatable agents, in

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contact with cells within the irradiation chamber,  
described in U.S. Patent 4,737,140 (JJC-14), by irradiating  
concurrently both sides of the irradiation chamber while  
still permitting facile removal of the chamber. A most  
5 preferred embodiment further comprises a solid state  
device for controlling the use of the light assay assembly  
for maintaining and protecting patient safety and device  
efficacy.

10 Detailed Description

Figure 1 shows various aspects of the system developed for  
extracorporeally treating a patient based in part upon the  
scientific discoveries of Edelson. While the specific  
15 design, construction and operation of the apparatus 10 is  
the result of a number of separate inventions some of  
which form the subject matter of previously described  
issued patents and Australian Patent No 566,710 entitled

- 20 "Concurrent On-Line Irradiation Treatment Process";  
AU 69506/87 (JJC-3) entitled "Electronic Device  
For Authenticating And Verifying Disposable Elements";  
U.S. Patent 4,705,498, entitled "Disposable Temperature  
Probe For Photoactivation Patient Treatment System";  
25 U.S. Patent 4,681,568 (JJC-5) entitled "Improved Valve  
Apparatus For Photoactivation Patient Treatment System";  
U.S. Patent 4,692,138 (JJC-7) entitled "Pump Block For  
Interfacing Irradiation Chamber to Photoactivation Patient  
Treatment System"; Australian application No. 69509/87 entitled  
30 "Demountable Peristaltic Pump For Photoactivation Patient  
Treatment System"; U.S. Patent 4,687,464 (JJC-9) entitled "Zero  
Insertion Force Socket For Photoactivation Patient  
Treatment System" and U.S. Patent 4,737,140 (JJC-14) entitled  
35 "Irradiation Chamber For Photoactivation Patient Treatment  
System"; the relevant parts of which are fully

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incorporated herein by reference, it is believed a brief description may be helpful.

5 The operation of the device and performance of the methods  
can be divided into two basic phases or modes, depicted in  
part by Figure 1. The first phase is shown substantially  
in Figure 1 wherein the patient is connected at the point  
shown, preferably by venipuncture or the like methods  
well-known and developed to a high degree in the dialysis  
10 arts. Patient blood, as it flows to the apparatus 10  
(alternately referred to herein as the puvapheresis  
apparatus or system) is preferably infused, under control  
of pump 11, with an anticoagulant agent contained in  
container 20 hung from stand 15. Control of the flow of  
15 patient blood to the remainder of apparatus 10 is  
controlled largely by clamping means 16a which has the  
dual function of also controlling flow in the reverse  
direction as well as flow to return container 21. Clamp  
16a acts as an "or" valve.

20 Normally the blood flows through tubing 24 through blood  
pump 12 (preferably a roller pump such as that described  
in U.S. Patent No. 4,487,558 to Troutner entitled  
"Improved Peristaltic Pump" and incorporated herein by  
25 reference) into continuous centrifuge 13. This continuous  
centrifuge, available commercially from suppliers such as  
Dideco, Haemonetics and others, is preferably capable of  
continuously separating blood based on the differing  
densities of the individual blood components.  
30 "Continuously", as used herein means that, as blood flows  
into the centrifuge through line 24, it accumulates within  
the rotating centrifuge bowl and is separated so that low  
density components are emitted after a certain minimum  
volume has been reached within the centrifuge bowl and as  
35 additional blood is added. Thus, the continuous

centrifuge in effect acts as a hybrid between a pure  
online system and a pure batch system. This occurs  
because the centrifuge bowl has a capacity to hold most,  
if not all, of the most dense portion, typically  
5 erythrocytes or red blood cells while emitting lower  
density portions such as plasma and leukocytes (white  
blood cells) as whole blood is continuously added. At  
some point, however, the reservoir volume of the  
centrifuge is filled with the higher density components  
10 and further separation cannot be effectively obtained.  
Prior to that point, the operator, by viewing the  
uppermost portion of the centrifuge bowl through the  
centrifuge cover, can detect qualitatively when the  
centrifuge emits plasma (as opposed to priming solution),  
15 leukocyte enriched portions and the remainder, i.e.,  
nonleukocyte enriched portions, including erythrocyte  
enriched portions. Based on the operator's observations,  
he or she enters through control panel 19 (specifically  
via panel portion 42) the identification of the individual  
20 blood portions as they are emitted from the centrifuge.  
This information is entered by keys 44 (e.g. PLASMA, BUFFY  
COAT or leukocyte enriched portion) on control panel 19,  
and in response thereto, the apparatus 10 controls valve  
mechanism 16c to direct the leukocyte enriched portion and  
25 a predetermined volume of plasma into plasma-leukocyte  
enriched container 22 while excess plasma, air, priming  
fluids, erythrocytes etc. are directed to container 21.

Once the centrifuge is no longer capable of further  
30 separation due to the attainment of its capacity, the  
operator directs that the bowl be emptied by suitable data  
key entry on panel 19 and the fluid contents of centrifuge  
13 are advantageously pumped into return container 21 by  
means of pump 12 under the control of valves 16a and c.  
35 The foregoing steps may be repeated a number of times or

blood and plasma is obtained for further treatment, in each instance the undesired portions being collected in return container 21.

5

Between cycles, the fluids, including erythrocytes which have been pumped into return bag 21 are gravity fed back to the patient through a drip infusion operation and controlled by valve 16b. It is preferred that gravity  
10 feed be employed rather than pumping the blood back to the patient via pump 12 in order to avoid potential pressurization problems at the infusion insertion site at the patient, and also to avoid foaming or other air related dangers.

15

As may be already appreciated, when initially set up, the centrifuge bowl and line 24 may be expected to contain sterilized air which is preferably removed by suitable priming operations advantageously accomplished by  
20 utilizing the anticoagulation agent in container 20; both the air and a portion of priming solution being collected in container 21.

25

Also to be noted is the predetermination of the desired leukocyte enriched volumes and plasma volume to be collected within container 22 as well as the number of cycles to be employed to collect same. These volumes are selected largely in accordance with the individual volume capacities of the containers as well as the treatment  
30 chamber to be described later. Accordingly, these volumes are set in order to preferably optimize handling efficiency and to ensure patient safety. For instance, one preferred selection would include the following settings: 250 ml total buffy coat or leukocyte enriched  
35 portion and 300 ml of plasma to be collected within

preferably on the order of three or four, bearing in mind that the more cycles that are selected, the lower the total volume of blood withdrawn from the patient at any one time. If blood collection meets the minimum capacity limits of the centrifuge bowl, the patient's capacity to withstand temporary blood volume depletions and the treatment procedure in general is increased. Further, more cycles will permit more discriminating selection of leukocyte enriched blood as it is emitted from the centrifuge. The buffy coat and plasma volumes as well as the number of cycles are typically physician selected. Accordingly, the controls governing these selections are preferably placed within the apparatus 10, such as behind door 18a where their inadvertent alteration may be advantageously avoided, especially since no operator interaction is normally required with respect to these data inputs.

20 The leukocyte enriched container 22 is connected via tubing line 34 to the flat plate treatment irradiation chamber behind assembly door 17 with a return line 35 to reservoir container 22.

25 Referring now to Figure 2, the leukocyte enriched blood, plasma, and priming solution contained in reservoir 22 (Figure 1) is delivered through line 34 to the inlet 209 of the flat plate irradiator 200. The cavity in the flat plate is relatively "thin" (e.g. on the order of approximately 0.04 inch) in order to present large surface area of leukocyte rich blood to irradiation and reduce the self-shielding effects encountered with lower surface area/volume ratios. The fluid flows upward through the serpentine pathway in cavity 208 in the irradiation chamber to the outlet 210. While a serpentine pathway is

preferred in order to avoid or minimize stagnant areas of  
flow, other arrangements are contemplated. Tubing from  
the outlet 211 passes through the pump block 201  
[described in greater detail in U.S. Patent 4,692,138  
5 (JJC-7)], affixed to the end of the flat plate irradiator  
200, and then connects to return line 35 which returns  
fluids from the irradiation chamber to container 22.

Recirculation pump rotor 203, which is located internally  
10 in the machine (mounting not shown), engages the tubing in  
the pump block in the semi-circular tract 212 and thereby  
provides and controls the recirculating flow of fluid,  
from container 22 up through irradiation chamber 200 and  
back to container 22. In a preferred embodiment, a metal  
15 segment 220 in the tubing line from outlet 211  
incorporates a thermocouple 213 [described more fully in  
U.S. Patent 4,705,498, which permits monitoring of  
the fluid temperature.

20 Sterile air initially contained in the irradiation chamber  
cavity 208 is displaced by entering fluid and stored in  
the top of container 22. By reversing the rotation of  
recirculation pump rotor 203, the air stored in container  
22 can be pumped back into the outlet 210 of the chamber  
25 200 thereby displacing all fluids back into container 22.  
Once fluid is initially delivered to container 22, the  
recirculation pump rotor 203 is energized filling the  
irradiation cavity 208 and displacing sterile air to  
container 22. When the irradiation chamber is filled and  
30 BUFFY COAT button 44 on panel 19 is pressed, the light  
array assembly which surrounds the irradiation chamber is  
energized. Continued operation of the recirculation pump  
rotor 203 continuously recirculates the leukocyte enriched  
fluid from container 22 through the chamber for receiving

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photoactivating radiation from the energized light array assembly 401 (Figure 3) and back to container 22.

Figure 3, illustrating the light array assembly 401 from a bottom view, shows two rows, in the most preferred embodiment although one row can be used, of radiation source 400 powered through contacts 216. Such sources are conveniently chosen so that illumination is reasonably constant over the entire irradiation cavity 208 (Figure 2). Suitable sources include the Sylvania FR15" T8/350BL/HO/108° with 2011 phosphorus bulb which is in the so-called fluorescent tube form. As is apparent from Figure 3, the irradiation chamber 200 slides between the rows of radiation source 400 so that pump block 201 engages pump rotor 203 driven by motor 250.

Thus, photoactivation of the leukocyte enriched fluid by irradiation is initiated at the outset and continues through and after the collection and separation process. In the most preferred mode, the light array assembly will comprise sources of ultraviolet radiation, most preferably of the UVA type for activating the photoactivatable agent presently of choice, 8-methoxy psoralen.

The flat plate irradiation chamber treatment module is described more fully in US Patent 4,737,140.

In operation, and with respect to Figure 1, the exposure time on the right hand portion of the panel 19 is set in accordance with physician determined criteria. The central control means of the apparatus 10, calculates and displays

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on one section of the panel 19, via central processing unit and memory stored software, the exposure time remaining at the onset of irradiation treatment and as the treatment progresses. Another section of the control panel  
5 also includes three operator controlled entry data keys whereby the operator can de-energize the light assembly array and stop the recirculation process if desired. Actual photoirradiation treatment preferably commences automatically under control of the central processing unit  
10 when fluid is first directed to container 22, continues while leukocyte enriched blood portion from container 22 is pumped through the irradiation chamber back into container 22, and terminates when the preset exposure time has expired. At that time, the light array assembly is  
15 de-energized and the recirculation pump reverses emptying the contents of the irradiation chamber 200 into container 22.

Thereafter container 22 is ideally removed to stand 15  
20 where it is connected to tube 36, provided on the common drip chamber 21a also associated with return container 21, for reinfusion of the treated blood portion into the patient.

25 To enhance patient safety and decrease the risk of contamination to the patient blood and blood portions, each time a connection is made or broken, it is preferably only done once. Thus, container 22 would ideally have four connection points or ports; one for the collection of  
30 the leukocyte enriched blood portion, two for connection to the flat plate irradiation chamber (feed and return), and the fourth for connection to the drip chamber (21a) for reinfusion of treated blood to the patient.

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With further reference to Figure 1, the control panel 19 of the apparatus 10 is shown with the keyboard entry buttons 44, each ideally having a light which, when lit, preferably indicates the stage of the operation.

5 Advantagously, the keyboard entry buttons 44 are preferably placed in sequential order thereby assisting the operator in learning the system and performing the steps in the correct order. Indeed, the central control microprocessor or computer will preferably be programmed  
10 to prevent out of step sequences from being implemented. A visual display indicates the volume of leukocyte enriched blood collected in container 22.

Panel 19 will preferably also contain a power switch, as  
15 well as a blood pump speed control whereby the operator may select the speed with which the blood is withdrawn from the patient and pumped through the system during collection. Also preferably included is an alpha-numeric display for indicating the machine's status and  
20 identifying alarm conditions throughout system operation. Optional accessory status lights, preferably provided in green, yellow, and red colors, provide at a glance the overall operating status of apparatus 10. Further included is a mute/reset button for quieting an audible  
25 alarm activated in the event an alarm condition occurs and operator input is required.

Other features may be readily apparent from the drawings such as the preferable inclusion of casters and caster  
30 brakes for enhancing the mobility of the apparatus. Further, side panel 23 will preferably include mechanical means (e.g. hanging pegs and the like) for assisting in the securement of container 22. It may also optionally be  
35 outfitted with a transparent or translucent opening 18b in the area beneath container 22 for providing at a glance

information regarding the illumination status of the irradiation treatment chamber during the treatment phase. For instance, if the window is of sufficient size, the operator may readily determine that each irradiation  
5 source within the treatment chamber is illuminated as desired. Naturally, the material comprising such window is preferably selected in order to contain harmful radiation, if any, within apparatus 10.

10 The aforescribed photopheresis blood treatment apparatus is made largely possible by an automated control method for directing the blood portions, derived from the continuous centrifuge, into particular containers. The automated method performs in accordance with preset volume  
15 determinations which are manually entered behind panel 18a pursuant to a physician's direction. These predetermined volumes specify the volume to be contained within container 22 by setting forth the volume of plasma and the volume of leukocyte enriched blood portion to be directed  
20 thereto. Additionally included within these condition setting parameters is preferably the ability to set forth the number of cycles of blood collection and separation required or desired in order to obtain the desired blood volumes.

25 The volumes collected are determined in accordance with the blood volume pumped by the blood pump. This may be suitably monitored and communicated to the central control means by specifically monitoring the number of step pulses  
30 input to the pump to cause rotations of the blood pump. Typically, 200 pulses results in one revolution. Rotation may also be conveniently monitored such as by attachment of a slotted disk to the shaft and the passage of slots determined by an optical sensor means such as that  
35 described in U.S. Patent No. 4,623,328 (ECP-107 fully

incorporated herein) and by monitoring shaft rotation. The resultant periodic signal may be conveniently correlated with speed and number of rotations by circuit designs well-known in the art. The number of rotations by  
5 any of the foregoing methods coupled "with the known volume pumping characteristics of the pump, will provide the necessary information regarding the volume of blood pumped. It will readily be appreciated that the sensors need not be optical but may be electronic or mechanical  
10 instead.

In actual operation, a most preferred procedure would be as follows. The operator presses the PRIME CENT. key on control panel section 19 which primes the tubing set, the  
15 blood pump, and the centrifuge with the anticoagulation solution contained in container 20. Displaced sterile air is collected in container 21. When priming solution emerges from the exit of the centrifuge, the operator presses PRIME U.V. key on control panel section 42 which  
20 closes the tubing line to container 21 and opens the tubing line to container 22 by means of valve 16c. Recirculation roller pump rotor 203 is energized to prime the flat plate irradiation chamber and displace sterile air to container 22. The priming process stops  
25 automatically after a preset volume of fluid is delivered to container 22.

Blood collection is started by the operator pressing START key on control panel 19. Thereafter, blood is withdrawn  
30 from the patient and pumped by the blood pump into the rotating centrifuge. As the blood enters the centrifuge, it displaces the priming solution which emerges first in accordance with its preferably lighter density. This priming solution is automatically directed into container  
35 22 until a preset volume is delivered, after which the

emerging solution is redirected to container 21 by means of valve 16c. At some point, the priming solution will be completely displaced from the rotating centrifuge and plasma will begin to emerge. This emergence may be directly observed through port 14 whereupon the operator presses the PLASMA key on control panel 19. Thereafter, the central control means automatically directs the plasma into container 22 by altering valve 16c keeping track of the volume as it does so since the volume entering the centrifuge equals the volume emerging therefrom. This continues until the operator indicates the leukocyte enriched portion, i.e. buffy coat has begun by pressing the respective data entry key in control panel section 42 whereupon, the leukocyte enriched portion continues to container 22, however, the volume so directed is monitored as buffy coat volume. Alternately, if all of the predetermined plasma volume is collected prior to the emergence of the buffy coat, then the central control means automatically diverts, by valve 16c, the emerging plasma fluid stream to container 21. In that instance, upon the emergence of the buffy coat and the keying of the BUFFY COAT data entry switch 44, the central control means diverts the emerging buffy coat into container 22, by means of valve 16c, again keeping track of its volume.

The collection of the buffy coat will preferably continue in accordance with both the predetermined buffy coat volume as well as the number of cycles, another condition predetermined by the physician. If this most preferred embodiment is employed, then a representative example might be as follows. Assume, that the predetermined volume and cycle conditions are set as follows: 350 mls of plasma, 250 mls of buffy coat, and 5 cycles. In each cycle, the apparatus will collect 250/5 or 50 mls of buffy coat before ending the cycle and thereupon emptying the

centrifuge bowl and returning all nonleukocyte fluids, predominantly erythrocytes and perhaps excess plasma, to the patient. Prior to the collection of the 50 mls, plasma will emerge from the centrifuge and will be  
5 collected in container 22 either until the full 350 mls are collected or, until the buffy coat emerges.

During the next cycle, the central control means will direct the further collection of plasma, if needed, in  
10 order to reach the 350 ml predetermined volume and then collect an additional 50 mls of buffy coat. The total volume to be contained within container 22, will then equal 600 mls and would be indicated on display 46 as it is accumulated.

15 Thus, the instant invention serves to automatically keep track of the volumes as they are collected thereby facilitating the institution of a convenient number of cycles whereby the removal of large blood volumes from the  
20 patient is avoided. Not only is patient safety enhanced thereby, but the automated nature of the procedure further increases safety since, in accordance with the programmed conditions supplied to the central control microprocessor, the operator need not attempt to keep track of plasma and  
25 leukocyte enriched volumes collected, while still being assured that the final solution for treatment will contain the predetermined and desirable leukocyte concentration.

The foregoing described automated methods used in the  
30 photopheresis apparatus described with respect to Figure 1 depends heavily upon the instant inventions, in particular a removable and disposable light array assembly for receiving the flat plate irradiation chamber and providing photoactivating radiation thereto.

35

With specific reference to Figure 4, the most preferred arrangement of the light array assembly is shown. A plurality of "fluorescent light" type lamps 400, preferably ultraviolet (U.V.) for activating psoralen but in any case, selected to photoactivate the activatable agent being employed, are mounted between two single sided fiberglass printed circuit boards 402 and 402'. The top and bottom circuit boards, 402 and 402' respectively, have tracks 207 for receiving in sliding arrangement the flat plate irradiator 200 (Figure 5). In the most preferred arrangement there are 22 irradiation sources or lamps arranged in, ideally, two rows of 11 for providing photoactivating illumination to both sides of the flat plate irradiator when slidably mounted in tracks 207. Track 207 is attached or molded into each circuit board and runs lengthwise along the central plane of the array. In the preferred arrangement, the irradiation sources are U.V. lamps of an internal reflector type arranged such that the emitted radiation is directed inward toward the central plane of the array where the flat plate irradiator is mounted. Pin contacts on each bulb 400 extend through the circuit boards and are advantageously solder connected to the circuitry of circuit boards 402 and 402'. As much as possible, the circuit boards are preferably cut away between the lamps to provide a plurality of holes 404 through which cooling air can flow through the array with minimal resistance. Electrical connection to the lamps is accomplished by plated circuitry extending from the lamp pins 403 to the finger type contacts 216 at the edge of the circuit board. Offset key slots 405 prevent the light array assembly from being installed upside down in the patient treatment apparatus of Figure 1, which would give incorrect electrical connections.

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In the most preferred embodiment as described in copending patent application Australian application No. 69506/87 incorporated herein by reference, memory device integrated circuit chip 215 is installed on one of the circuit boards to retain encoded information specific for the particular light array assembly such as type, serial number, certification number and usage time. The memory device is electronically connected to the central control processor also by finger contacts 216 which engage in electrical contact sockets (not shown) with the patient treatment system shown in Figure 1. Two of the finger contacts are connected directly together by a plated circuit path 406 so that the array, when installed in the patient treatment system complete a circuit which signals the central control means that a light array assembly is installed properly within the photopheresis patient treatment apparatus.

Numerous advantages are obtained by the present invention. The lamps and circuit boards constitute a rigid and easily handled assembly requiring no additional structural elements. This provides maximum ease of handling and assembly at minimum costs. The complete array of lamps can be installed in one simple plug-in step making lamp replacement by less trained personnel a simple procedure. Moreover, the preferred embodiment makes it quite difficult to only partially change a lamp array, for example one or two lamps, thereby ensuring a safe and effective irradiation field of known history and performance. Large and numerous openings in the array structure facilitate proper cooling of the lamps and irradiation chamber. Central tracks provide proper positioning of the irradiation chamber at an optimal distance to the lamps determined in accordance with the thickness of the irradiation chamber and predetermined



experimental evaluation of photoactivating efficiency. Directly connected contacts signal proper array installation while optimal key slots assist in preventing incorrect installation. Advantageously, the incorporated  
5 memory device provides information for the central control of the apparatus to determine authenticity and suitability of the light array assembly for initial use, as well as remaining effective usage life. The memory device also identifies variations in the type of light array, e.g.  
10 different lamps for providing different activating wavelength radiation for different photoactivatable agents which might signal corresponding variations in treatment procedures, irradiation times and the like.

15 Upon study of the accompanying figures, and the foregoing description, it will become readily apparent to the skilled artisan that numerous alternatives may be made to the foregoing such as different number of lamps in the array, or utilizing only a single row of lamps in the  
20 array, etc. without departing from either the spirit or scope of the instant invention.



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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A light array assembly for use in a patient  
treatment system for altering cells including treating the  
5 cells with a photoactivatable agent and irradiating said  
cells and said agent whereby said agent is caused to be  
activated and to affect said cells, said agent and said  
cells during irradiation being contained in an irradiation  
chamber, comprising a top printed circuit board and a bottom  
10 printed circuit board having mounted therebetween a  
plurality of radiation sources for providing photoactivating  
illumination, said printed circuit boards having a plurality  
of contacts adapted to receive electrical power for  
energizing said radiation sources.

15

2 The assembly as described in Claim 1 wherein said  
circuit boards further comprise plated circuitry, said  
irradiation sources are of tubular design, each end thereof  
containing at least one contact pin for receiving electrical  
20 power, and wherein said plated circuitry connects said pins  
to said means for receiving electrical power.

20

3. The array of Claim 2 wherein said circuit boards  
further comprise track means for receiving said irradiation  
25 chamber.

25

4. The array of Claim 3 wherein said array further  
comprises integrated circuit means for providing information  
characteristic for said array.

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5. The array as described in claim 4 wherein said plurality of irradiation sources are arranged to have a planar space therebetween for receiving said irradiation chamber and wherein said track means passes between said plurality of irradiation sources, and wherein said circuit board means further comprises orientation means for preventing incorrect mounting of said array in said patient treatment system.

6. The array of Claim 2 wherein said irradiation sources provide ultraviolet radiation.

7. A light array assembly for use in a patient treatment system substantially as herein described with reference to the accompanying drawings.

DATED this 13th day of November 1989

MCNEILAB, INC  
By their Patent Attorney  
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7493S



FIG-1

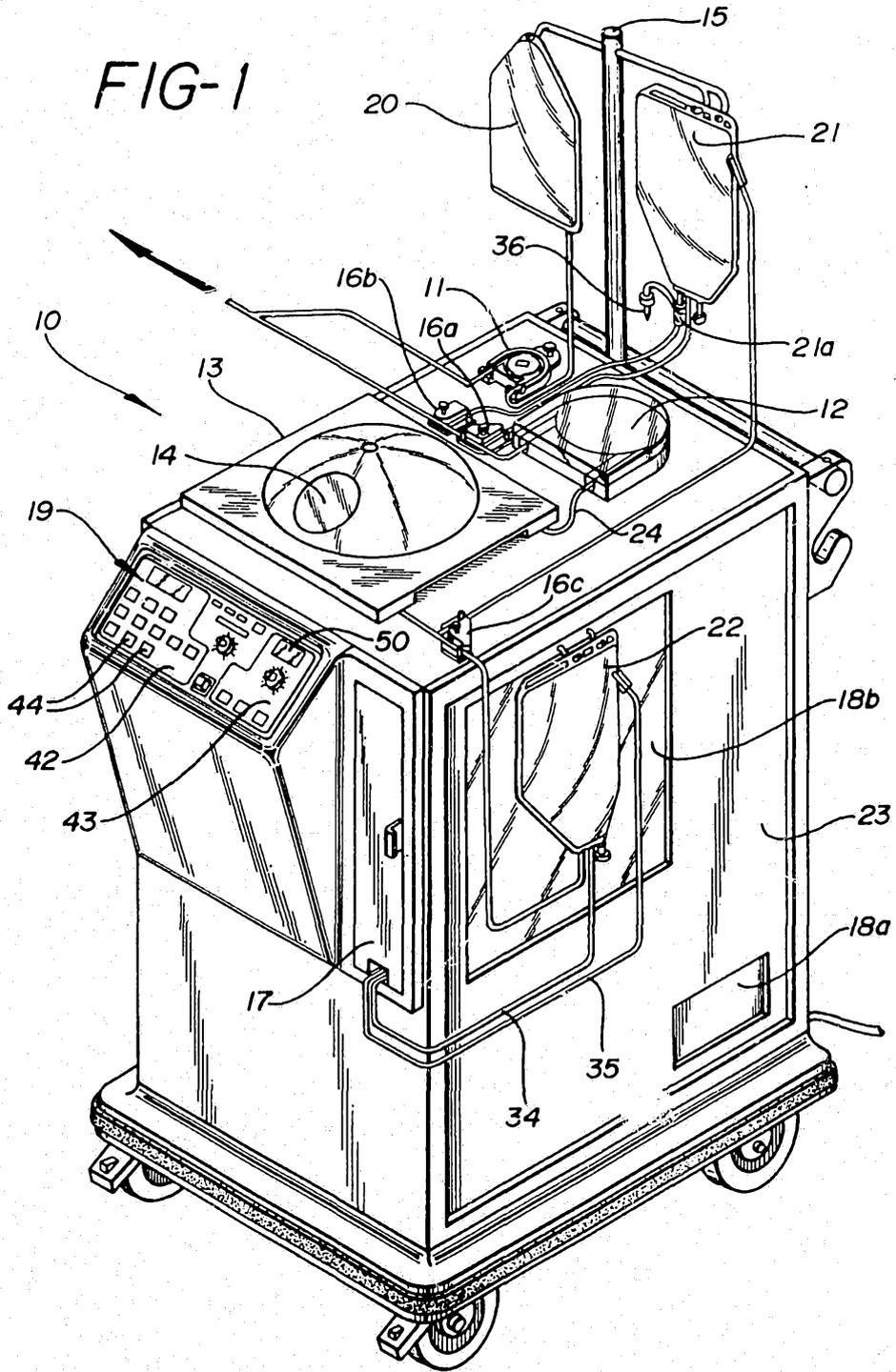
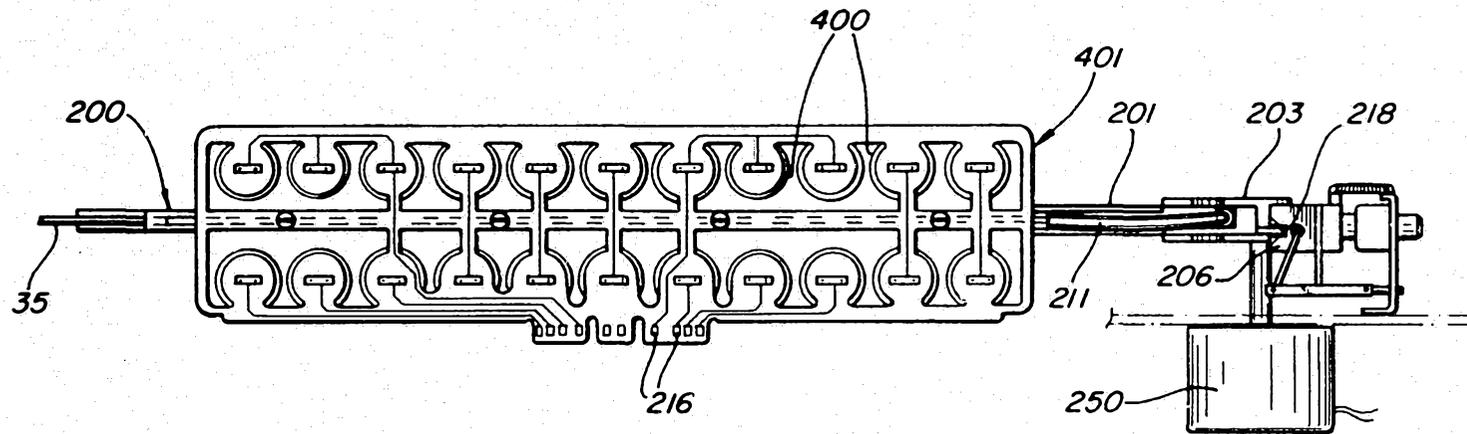
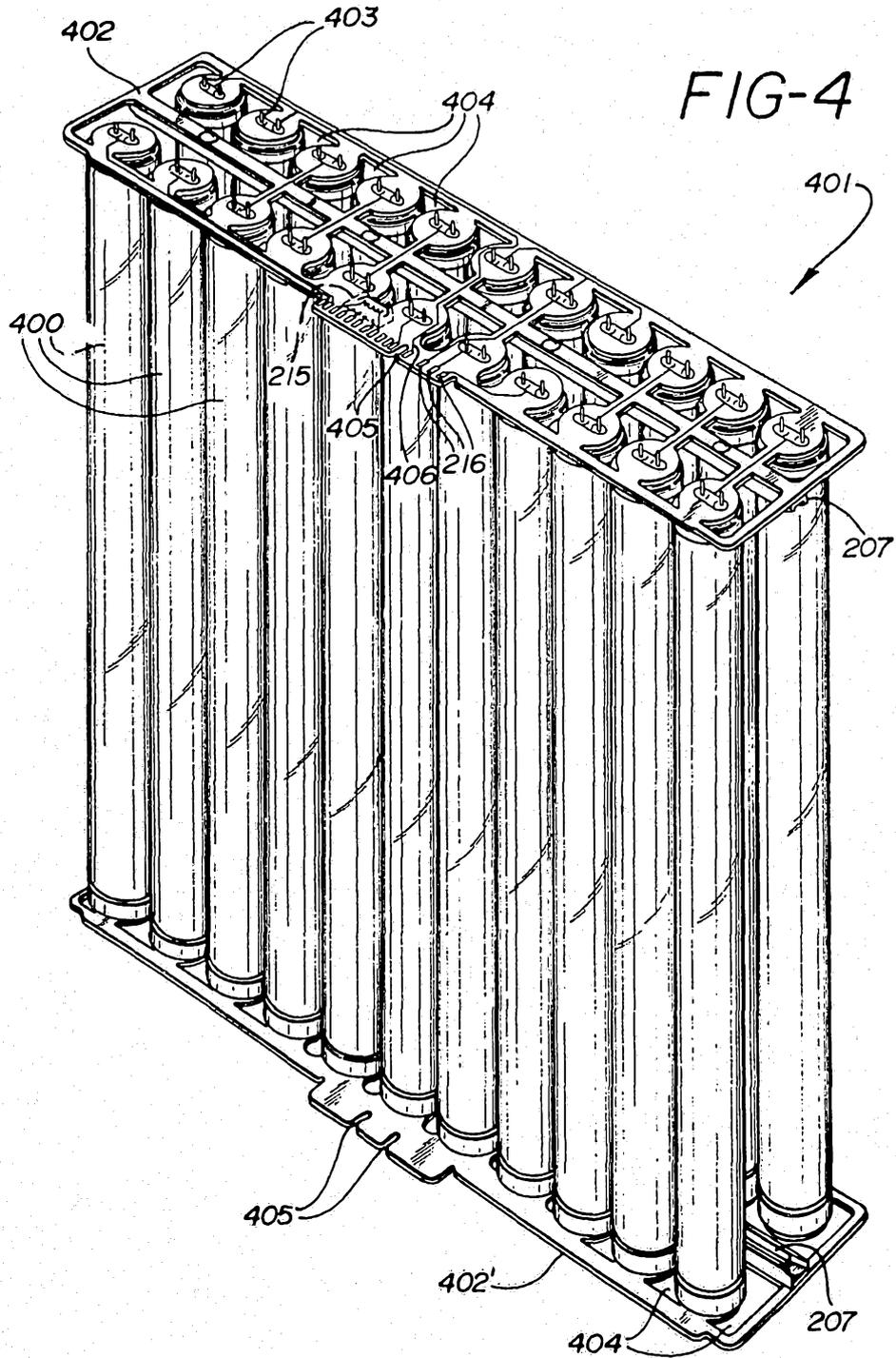


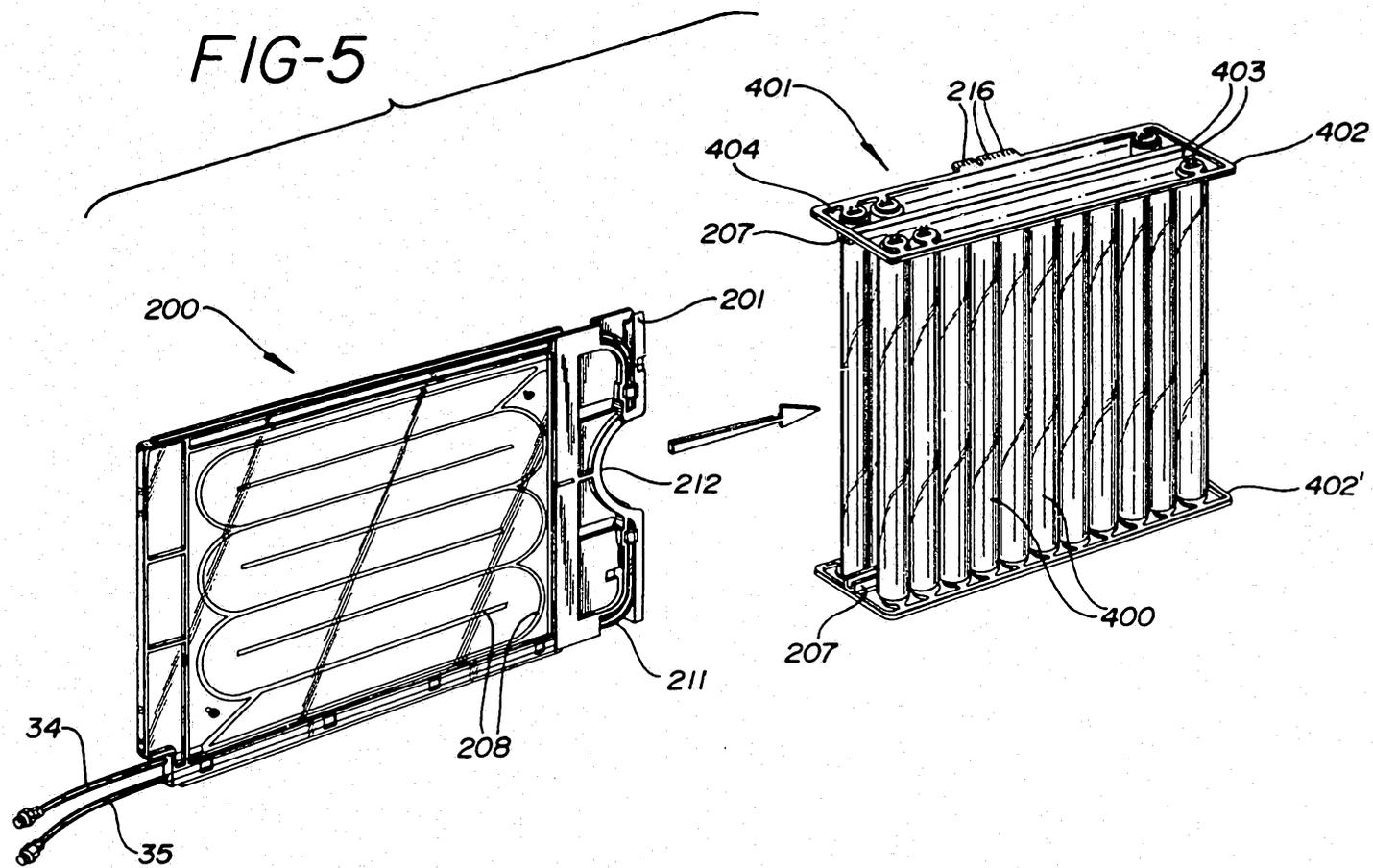


FIG-3



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