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Date: December 9, 2025

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- CN1540119A

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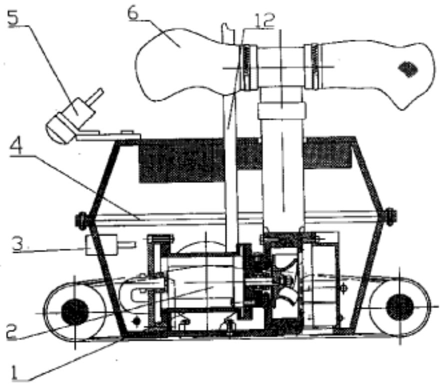
[54] Title of Invention
POOL CLEANER WITH DEBRIS DETECTION CAPABILITY

[57] Abstract
The present invention relates to a pool cleaner with a debris detection capability, which can be used in professional or commercial swimming pools and reservoirs with similar requirements. The pool cleaner is composed of a sealed motor cover, a brushless DC water pump motor, an infrared ranging sensor, a housing, a water circulation outlet, a filter bag, an industrial control computer and associated software, a PT resistance pool water temperature sensor, a pool water quality pH sensor, a track-type crawling mechanism, a roller brush, a cable assembly, a plug assembly, and a hybrid stepper motor. The pool cleaner is characterized in that a debris detection device is provided on the enclosure. The present invention has the advantage of adopting intelligent adaptive technology with computer control and AC/DC low-voltage driving so that a corresponding cleaning force can be selected according to a varying distribution of debris on the pool bottom. The present invention has a simple structure, strong applicability, and high reliability.



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1. A pool cleaner with a debris detection capability, wherein the pool cleaner is composed of a sealed motor cover (1), a brushless DC water pump motor (2), an infrared ranging sensor (3), an housing (4), a water circulation outlet, a filter bag (6), an industrial control computer (7) and associated software, a PT resistance pool water temperature sensor (8), a pool water quality pH sensor (9), a track-type crawling mechanism (10), a roller brush (11), a cable assembly (12), a plug assembly (14), and a hybrid stepper motor (15), and the pool cleaner is characterized in that a debris detection device is provided on the housing (4).

2. The pool cleaner with the debris detection capability according to claim 1, characterized in that the debris detection device may be a charge-coupled device (CCD) camera (5) or a dedicated turbidity sensor (13) and associated software.

3. The pool cleaner with the debris detection capability according to claim 1, characterized in that the industrial control computer (7) comprises a human-machine interface (16), an enclosure (17), a three-axis stepper motor control card (18), a multi-channel A/D converter card (19), a relay terminal board (20), and an image acquisition card (21), wherein the three-axis stepper motor control card (18) is connected to the hybrid stepper motor (15), the multi-channel A/D converter card (19) is separately connected to the infrared ranging sensor (3), the PT resistance pool water temperature sensor (8), and the pool water quality pH sensor (9), the relay terminal board (20) is connected to the brushless DC water pump motor (2), and the image acquisition card (21) is connected to a charge-coupled device (CCD) camera (5).

4. The pool cleaner with the debris detection capability according to claims 1 or 2, characterized in that the dedicated turbidity sensor (13) is composed of a tungsten halogen light source (22), a assembled casing (23), a sealing ring (24), an optical lens (25), a protective window (26), a water flow detection port (27), a silicon photovoltaic panel (28), a multi-stage signal amplification circuit board (29), and a cable (30), wherein the tungsten halogen light source (22) is provided in the middle of the assembled casing (23), the protective window (26) is provided at one end of the assembled casing (23), the optical lens (25) is provided adjacent to the protective window (26), the tungsten halogen light source (22) and the optical lens (25) are provided on a same center wire, the sealing ring (24) is provided between the tungsten halogen light source (22) and the optical lens (25), and the silicon photovoltaic panel (28) and the multi-stage signal amplification circuit board (29) are provided on the other side of the water flow detection port (27), and are separately connected to the cable (30) through sockets.

5. The pool cleaner with the debris detection capability according to claims 1, 2 or 4, characterized in that

the multi-stage signal amplification circuit board (29) is composed of three amplifiers U1-U3, six capacitors C1-C6, and a plurality of resistors R1-R14, wherein a blue wire provides +6 V positive polarity power supply through a resistor network of R8, R9, R10, and R11, a gray wire provides -6 V positive polarity power supply through a resistor network of R12, R13, and R14, a zero-adjustment resistor R0 is connected between a green wire and a yellow wire, a photovoltaic cell is connected to R and R3, the green wire is connected to R1, C1, R2, and C2, and is also connected to U1, U2 is connected to R4, R5, and RR, and is also connected to C4, U3 is connected to R1, R7, and C3, and is also connected to C5 and C6, and C3 is connected to a purple wire.

POOL CLEANER WITH DEBRIS DETECTION CAPABILITY

Technical Field

The present invention relates to a pool cleaner with a debris detection capability, which can be used in professional or commercial swimming facilities and water reservoirs with similar requirements, and belongs to the technical field of intelligent electrical appliances.

Background Art

The bottom and walls of swimming pools are subject to corrosion, contamination, and sedimentation of all types of impurities and substances in water, and as such need regular cleaning. The traditional means of cleaning a swimming pool is manual labor, with workers needing to drag brush cleaning heads with pump-driven suction tube to draw water together with the debris. All these entail heavy manual work with low efficiency and waste of water resources. Pool cleaners recently developed overseas and locally use micro-controller to enable them to automatically detect the pool's surface area and automatically set cleaning duration and operating mode. However, as debris distribution is uneven, if the entire working process of the cleaner is controlled solely based on the swimming pool's area to set the time, for the majority of the time of operation, the proportion of actual cleaning is low, thereby yielding low cleaning efficiency.

Summary of the Invention

An objective of the present invention is to provide a pool cleaner with a debris detection capability that applies different cleaning forces for different debris distributions.

To achieve the above objective, the technical solution of the present invention is to provide a pool cleaner with a debris detection capability, which is composed of a sealed motor cover, a brushless DC water pump motor, an infrared ranging sensor, a housing, a water circulation outlet, a filter bag, an industrial control computer and associated software, a PT resistance pool water temperature sensor, a pool water quality pH sensor, a track-type crawling mechanism, a roller brush, a cable assembly, a plug assembly, and a hybrid stepper motor. The pool cleaner is characterized in that a debris detection device is provided on the housing.

The debris detection device may be a charge-coupled device (CCD) camera or a dedicated turbidity sensor together with associated software.

The industrial control computer comprises a human-machine interface, an enclosure, a three-axis stepper motor control card, a multi-channel A/D converter card, a relay terminal board, and an image acquisition card. The three-axis stepper motor control card is connected to the hybrid stepper motor. The multi-channel A/D converter card is separately connected to the infrared ranging sensor, the PT resistance pool water temperature sensor, and the pool water quality pH sensor. The relay terminal board is connected to the brushless DC water pump motor, and the image acquisition card is connected to a charge-coupled device (CCD) camera.

The present invention has the advantage of adopting intelligent adaptive technology with computer control and AC/DC low-voltage driving so that a corresponding cleaning force can be selected according to a varying distribution of debris on the pool bottom. The present invention has a simple structure, strong applicability, and high reliability.

Brief Description of Drawings

Fig. 1 is a schematic structural diagram of a pool cleaner with a debris detection capability in which a charge-coupled device (CCD) camera is mounted;

Fig. 2 is a top view of a pool cleaner with a debris detection capability;

Fig. 3 is a schematic structural diagram of a pool cleaner with a debris detection capability in which a dedicated turbidity sensor is mounted;

Fig. 4 shows a display diagram of a human-machine interface of an industrial control computer;

Fig. 5 shows a structural diagram of an industrial control computer;

Fig. 6 is a block diagram showing the connection between a pool cleaner with a debris detection capability and an industrial control computer;

Fig. 7 shows a flowchart of control software;

Fig. 8 is a schematic structural diagram of a dedicated turbidity sensor;

Fig. 9 is a test principle diagram of a dedicated turbidity sensor;

Fig. 10 shows a multi-stage signal amplification circuit diagram; and

Fig. 11 shows a flowchart of a method for debris detection by a dedicated turbidity sensor.

Detailed Description of Embodiments

The present invention will be further described below in combination with the drawings and two embodiments.

Embodiment 1:

A pool cleaner with a debris detection capability in which a charge-coupled device (CCD) camera is mounted is taken as an example.

The present invention adopts the charge-coupled device (CCD) camera which, during the operation of the cleaner, continuously captures images of areas to be cleaned located directly in front and below a crawling direction of the cleaner. These images are then converted through A/D conversion to produce up to 256 levels of grayscale, and continuously compared with pre-stored standard image information of a pool bottom. Finally, through computer system processing, the crawling speed of the cleaner is controlled so as to enable the cleaner to apply different cleaning forces according to different distributions of debris.

A schematic structural diagram of a pool cleaner with a debris detection capability, in which a charge-coupled device (CCD) camera is mounted, is as shown in Figs. 1 and 2. The pool cleaner is composed of a sealed motor cover 1, a brushless DC water pump motor 2, an infrared ranging sensor 3, a housing 4, the charge-coupled device (CCD) camera 5, a water circulation outlet, a filter bag 6, an industrial control computer 7 and associated software, a PT resistance pool water temperature sensor 8, a pool water quality pH sensor 9, a track-type crawling mechanism 10, roller brushes 11, a cable assembly 12, a plug assembly 14, and hybrid stepper motors 15. The sealed motor cover 1 covers the brushless DC water pump motor 2. The hybrid stepper motors 15 are mounted on both sides of the sealed motor cover 1, respectively. The infrared ranging sensor 3 is mounted on the front side of the housing 4, and the charge-coupled device (CCD) camera 5 is mounted at the upper front end of the housing 4. The PT resistance pool water temperature sensor 8 and the pool water quality pH sensor 9 are mounted at the lower part of the housing 4, and their upper ends are connected to the water circulation outlet and the filter bag 6. The track-type crawling mechanism 10 is mounted at the front and rear ends of the housing 4, and the roller brushes 11 are mounted on both sides. The cable assembly 12 is mounted in the middle portion of the housing 4. A power box supplies power to both the pool cleaner and the industrial control computer 7. The industrial control computer 7 is connected to the pool cleaner through the cable assembly 12 and the plug assembly 14.

A display diagram of a human-machine interface of the industrial control computer is as shown in Fig. 4, wherein the middle of the panel diagram shows the area of a pool to be cleaned, the cleaned area is denoted by light blue, and the area that has not been cleaned yet is denoted by dark blue so that the working status of the cleaner can be seen at a glance. Automatic and manual switches are provided on the left of the panel diagram, “start”, “stop”, and “continue” switches are provided on the right thereof, and the water temperature, cleaning duration and pool water quality pH value are displayed at the top thereof.

A structural diagram of the industrial control computer is as shown in Fig. 5. The industrial control computer is composed of a human-machine interface 16, an enclosure 17, a three-axis stepper motor control card 18, a multi-channel A/D converter card 19, a relay terminal board 20, and an image acquisition card 21.

A block diagram of the connection between the pool cleaner with the debris detection capability and the industrial control computer is as shown in Fig. 6. The three-axis stepper motor control card 18 is connected to the hybrid stepper motor 15, the multi-channel A/D converter card 19 is separately connected to the infrared ranging sensor 3, the PT resistance pool water temperature sensor 8, and the pool water quality pH sensor 9. The relay terminal board 20 is connected to the brushless DC water pump motor 2, and the image acquisition card 21 is connected to the charge-coupled device (CCD) camera 5.

During the cleaning operation, the charge-coupled device (CCD) camera 5 provided at the front end of the cleaner first selects image(s) of a clean surface of a pool bottom as original standard image(s) and stores it (them) in the industrial control computer 7. During the cleaning operation, the CCD camera 5 captures image(s) of an area to be cleaned located directly in front of and below the crawling direction of the cleaner. The video signal undergoes A/D conversion through the high-speed image acquisition card 21 and, in conjunction with corresponding image processing software, is compared with the original standard image(s) of the pool bottom stored in the industrial control computer 7. When there is a lot of sediment at the pool bottom, the grayscale level of the real-time captured image(s) is greatly different from the grayscale level of the original standard image(s), resulting in a high comparison output voltage. Otherwise, the output voltage is low. The voltage signal is sent to the industrial control computer 7 for processing by associated software. A pulse signal command output after processing goes through the relay terminal board 20 to separately control the drive of the two hybrid stepper motors 15 on the left and right sides of the cleaner. The crawling speed of the cleaner indirectly reflects the magnitude of the cleaning force. At the same time, in conjunction with the infrared ranging sensor 3, the cleaner can move forward, backward, or turn left and right.

Taking a standard rectangular swimming pool as an example, the control software flowchart in Fig. 7 is used to explain the working mode and cleaning procedure of the pool cleaner with a self-adaptive cleaning capability.

After power is turned on, a cleaning mode with a self-adaptive cleaning capability is selected. The cleaner starts working. First, the pool area is measured by $S=a\times b$, where a is the length of the rectangular pool and b is the width of the rectangular pool. After measurement is completed, the PT resistance pool water temperature sensor 8 and the pool water quality pH sensor 9 simultaneously measure the water temperature and the pool water quality pH value. The human-machine interface displays a simulated graph of the pool area, the water temperature, and the pool water quality pH value. The cleaner enters the cleaning procedure.

During cleaning, the charge-coupled device (CCD) camera 5 continuously captures images of an area to be cleaned located directly in front of and below the crawling direction of the cleaner. The video signal undergoes A/D conversion through the high-speed image acquisition card 21 and is processed by the industrial control computer 7 and associated software. It then goes through the relay terminal board 20 to separately control the speed of the two hybrid stepper motors 15 on the left and right sides of the cleaner to achieve self-adaptive cleaning. That is, different cleaning forces correspond to different debris distributions. When the cleaner crawls near a pool wall, the infrared ranging sensor 3 emits a switch signal, and under the condition that the turning radius of the cleaner is met, through different coordination of the left and right track wheels, a left or right turn of 180° is realized, reverse cleaning is then performed, and so on, until the entire pool is cleaned.

The pool area simulation graph continuously displays the cleaned area and cleaning time. The cleaned area $S'=0.6R\int\theta dt$, where R is the radius of a driving wheel and θ is the step angle of the stepper motor. When the entire pool area simulation graph turns light blue, the cleaner's work is completed.

Embodiment 2:

A pool cleaner with a debris detection capability in which a dedicated turbidity sensor is mounted is taken as an example.

This embodiment adopts the dedicated turbidity sensor. During the operation of the cleaner, a suspended water flow generated by the combined action of the scrubbing of a front roller brush and the removal of debris by a water pump suction port is used as a detection object. The turbidity of the water quality of the water flow formed by the cleaner in this state is instantly detected. The turbidity of the water flow is converted into a voltage signal by utilizing the photosensitivity principle of a photocell, and the voltage signal is sent to an industrial control computer for processing to control the crawling speed of the cleaner.

The cleaner crawls more slowly in a place with turbid water, thereby meeting the requirement of applying different cleaning forces for different degrees of debris.

A structural schematic diagram of a pool cleaner with a debris detection capability in which a dedicated turbidity sensor is mounted is as shown in Figs. 2 and 3. The pool cleaner is composed of a sealed motor cover 1, a brushless DC water pump motor 2, an infrared ranging sensor 3, a housing 4, a water circulation outlet, a filter bag 6, an industrial control computer 7 and associated software, a PT resistance pool water temperature sensor 8, a pool water quality pH sensor 9, a track-type crawling mechanism 10, a roller brush 11, a cable assembly 12, a dedicated turbidity sensor 13, a plug assembly 14, and a hybrid stepper motor 15. The dedicated turbidity sensor 13 is mounted at the front end of a lower suction port of the brushless DC water pump motor 2, while the connection relationships among other components remain unchanged.

A structural schematic diagram of the dedicated turbidity sensor is as shown in Fig. 8. The dedicated turbidity sensor 13 is composed of a tungsten halogen light source 22, an assembled casing 23, a sealing ring 24, an optical lens 25, a protective window 26, a water flow detection port 27, a silicon photovoltaic panel 28, a multi-stage signal amplification circuit board 29, and a cable 30. The tungsten halogen light source 22 is provided in the middle of the assembled casing 23. The protective window 26 is provided at one end of the assembled casing 23, and the optical lens 25 is provided adjacent to the protective window 26. The tungsten halogen light source 22 and the optical lens 25 are provided on the same center wire, and the sealing ring 24 is provided between the tungsten halogen light source 22 and the optical lens 25. The silicon photovoltaic panel 28 and the multi-stage signal amplification circuit board 29 are provided on the other side of the water flow detection port 27, and are separately connected to the cable 30 through sockets.

Fig. 9 is a test principle diagram of a dedicated turbidity sensor. Scattered light emitted by the tungsten halogen light source 22 is refracted into a group of parallel light beams by the optical lens 25. The light beams pass through the protective window 26, through the water flow detection port 27, and reach the silicon photovoltaic panel 28 facing it. The intermediate water medium flowing through the water flow detection port is an object to be detected. The silicon photovoltaic panel 28 may convert a light signal into a current signal. When there are many suspended substances in the water flow, the turbidity is high, the intensity of a photoelectric signal reaching the silicon photovoltaic panel 28 is weak, and the output current is small. Conversely, the output current is large. The current signal is then adjusted and amplified by the multi-stage signal amplification circuit board 29 and output in the form of an analog voltage signal and sent to the industrial control computer 7 for processing.

To ensure that the water flow at the water pump suction port all passes through the detection port of the dedicated turbidity sensor 13, the dedicated turbidity sensor 13 is mounted in front of the water pump suction port. The protective window 26 is made of high-hardness quartz glass, which can resist the wear of fine sand and stones in the water flow and maintain the stability of the light flux for a long time.

A circuit diagram of the multi-stage signal amplification circuit is as shown in Fig. 10. The multi-stage signal amplification circuit board 29 is composed of three amplifiers U1–U3, six capacitors C1–C6, and several resistors R1–R14. A blue wire provides a +6 V positive polarity power supply through a resistor network of R8, R9, R10, and R11, and a gray wire provides a

-6 V positive polarity power supply through a resistor network of R12, R13, and R14. A zero-adjustment resistor R0 is connected between a green wire and a yellow wire to achieve the calibration of the output range of a signal from the dedicated turbidity sensor 13. A photovoltaic cell is connected to R and R3, and the green wire is connected to R1, C1, R2, and C2, is also connected to U1. U2 is connected to R4, R5, and RR, and also connected to C4. U3 is connected to R1, R7, and C3, and also connected to C5 and C6. C3 is connected to a purple wire.

Fig. 11 is a flowchart of a method for debris detection using the dedicated turbidity sensor. When a ±6 V voltage of a switching power supply is connected between a white wire (+) and a black wire (–) of the dedicated turbidity sensor 13, the high-brightness tungsten halogen light source 22 is lit up, providing a light source required for an optical circuit of the dedicated turbidity sensor. The light passes through the optical lens 25, is refracted, and is focused onto the silicon photovoltaic panel 28. The silicon photovoltaic panel 28 converts a photoelectric signal into an electric signal, which is collected by a sampling resistor R. In the signal amplification circuit, R1, C1, R2, and C2 form a resistor-capacitor filter, R3 and R6 are shunt resistors, and C4, C5, and C6 are filter capacitors for U1, U2, and U3. The balancing resistors R4, R5, and RR perform linear compensation on the signal of the amplifiers. After the signal is amplified by U1 and U2, and compared and amplified by U3, it then passes through R7 and C3 for filtering. The purple wire outputs the signal to the multi-channel A/D converter card 19 of the industrial control computer 7. The computer may then determine different cleanliness levels of the water in the pool according to the signal strength from the dedicated turbidity sensor 13, and output corresponding pulses to adjust the rotational speed of the hybrid stepper motor 15, thereby improving the working efficiency of cleaning. When the tungsten halogen light source 22 is powered off, it indicates that the measurement has ended.

Before work begins, R0 in the multi-stage signal amplification circuit board 29, i.e., the measurement range of the dedicated turbidity sensor 13, is first calibrated. Then, the cleaning process is controlled through computer software processing according to the signal output range.

During the cleaning work, the suspension of debris and water from the scrubbing of the roller brush is drawn into the water pump suction port. In this case, the dedicated turbidity sensor 13 mounted at the water pump suction port converts the water flow's different turbidity degrees into a varying voltage signal. This voltage signal is then converted and filtered by the A/D converter card 19, sent to the industrial control computer 7, and processed by associated software. A pulse signal or a "start/stop" command output after processing go through the relay terminal board 20 to control the drive of the brushless DC water pump motor 2. When the turbidity of the water flow is high, the crawling speed of the cleaner slows down and the cleaning force increases. Otherwise, the cleaning force decreases. At the same time, the infrared ranging and steering photoelectric sensor 3 may be used to realize the forward, backward or left and right steering of the cleaner.

Taking a standard rectangular swimming pool as an example, the control software flowchart in Fig. 7 is used to explain the working mode and cleaning procedure of the pool cleaner with the debris detection capability.

After an automatic cleaning mode is selected, the cleaner is powered on to start working. First, the pool area is measured by

S=a×b, where a is the length of the rectangular pool and b is the width of the rectangular pool. After the measurement is completed, the PT resistance pool water temperature sensor 8 and the pool water quality pH sensor 9 simultaneously measure the water temperature and the pool water quality pH value. The human-machine interface displays a pool area simulation graph, the water temperature and the pool water quality pH value. Once the cleaner enters the cleaning procedure, the dedicated turbidity sensor 13 continuously carries out detection of the water that is about to enter the water pump suction port. The changes in the turbidity cause changes in a voltage output by the dedicated turbidity sensor 13. The voltage signal is sent to the A/D converter card 19 for conversion and filtering into a digital pulse signal. The signal then goes through the relay terminal board 20 to a driving module for amplification before controlling the rotational speed of the brushless DC water pump motor 2, so as to achieve different cleaning forces. When the cleaner crawls near a pool wall, the infrared ranging sensor 3 emits a switch signal, and under the condition that the turning radius of the cleaner is met, through different coordination of the left and right track wheels, a left or right turn of 180° is realized, reverse cleaning is then performed, and so on, until the entire pool is cleaned.. The pool area simulation graph continuously displays the cleaned area and cleaning time. The cleaned area is $S'=0.6R\int\theta dt$, where R is the radius of a driving wheel and θ is the step angle of the stepper motor. When the entire pool area simulation graph turns light blue, the cleaner's work is completed.

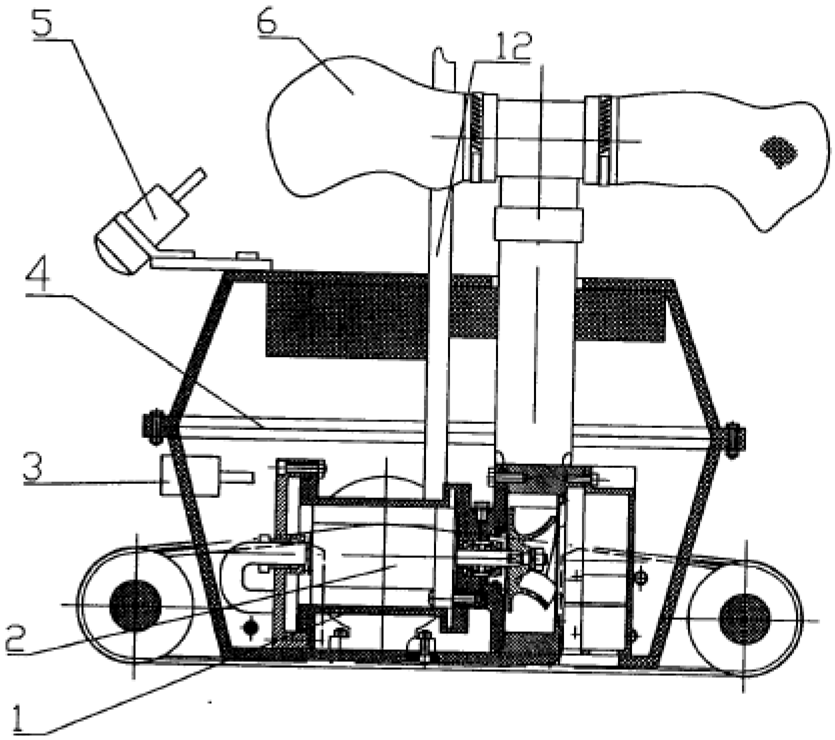

Fig. 1

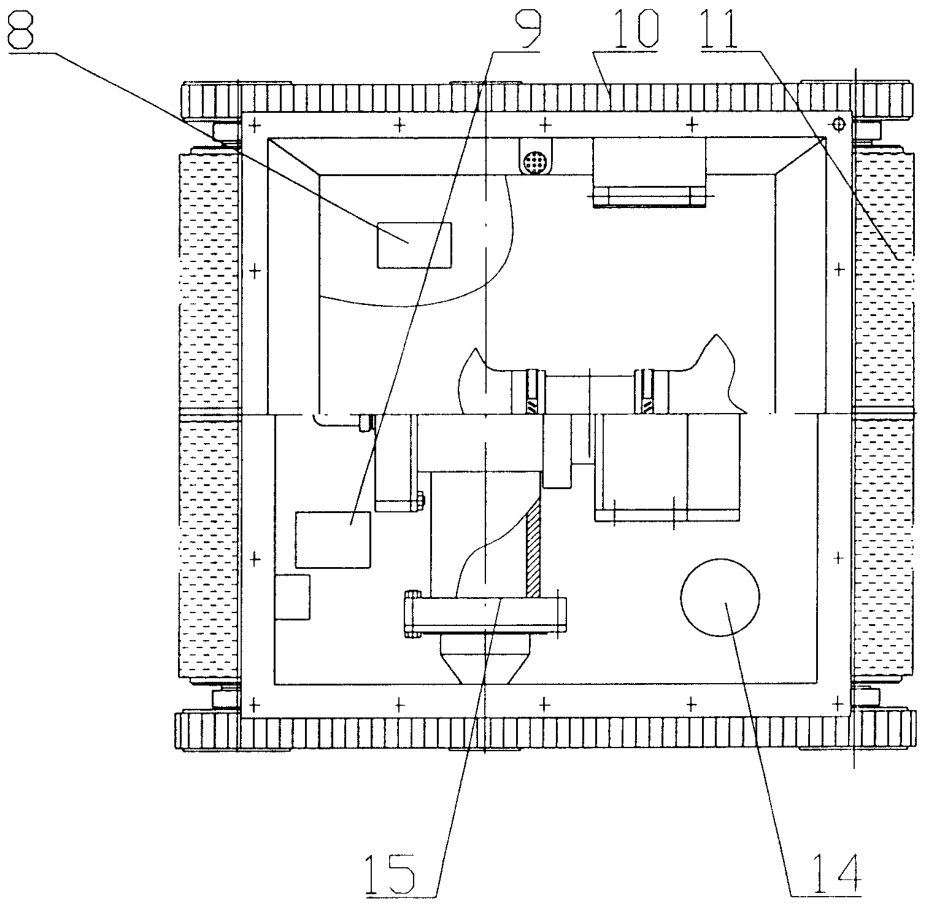

Fig. 2

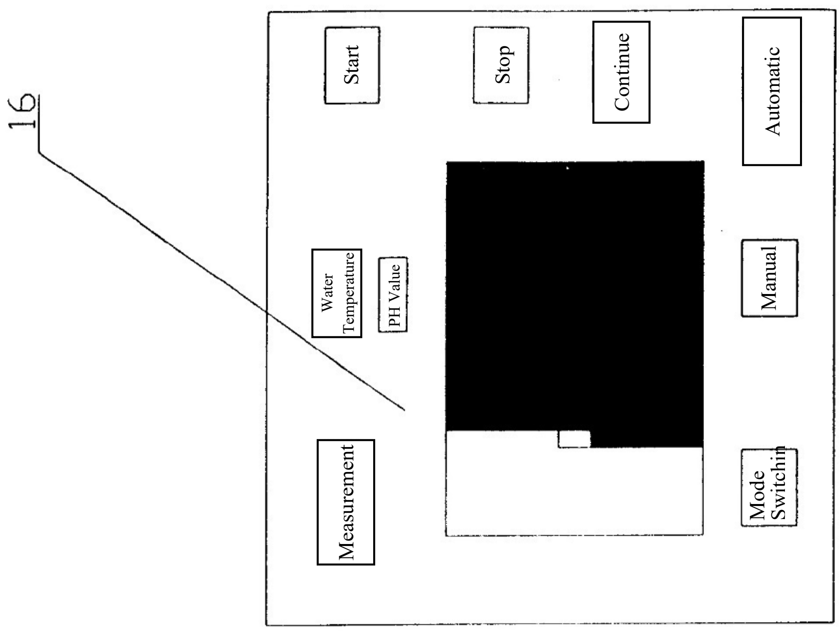
16
Start
Stop
Continue
Automatic
Water Temperature
PH Value
Manual
Measurement
Mode Switchin

Fig. 4

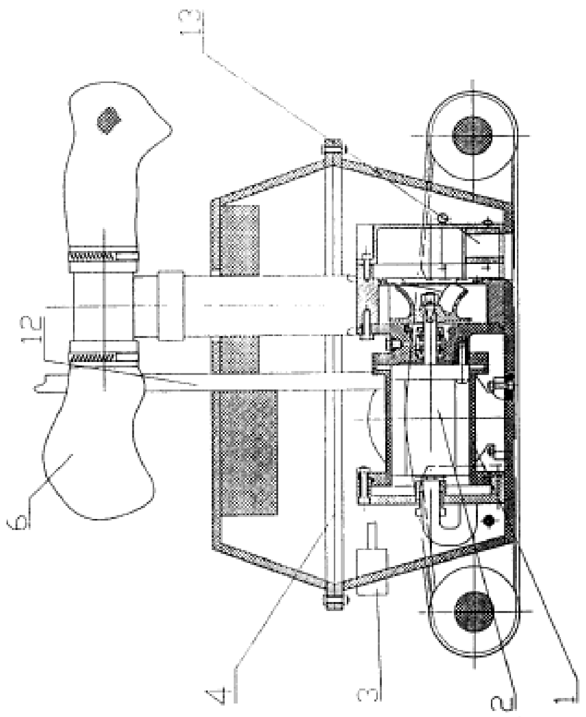
13
12
6
4
3
2
1

Fig. 3

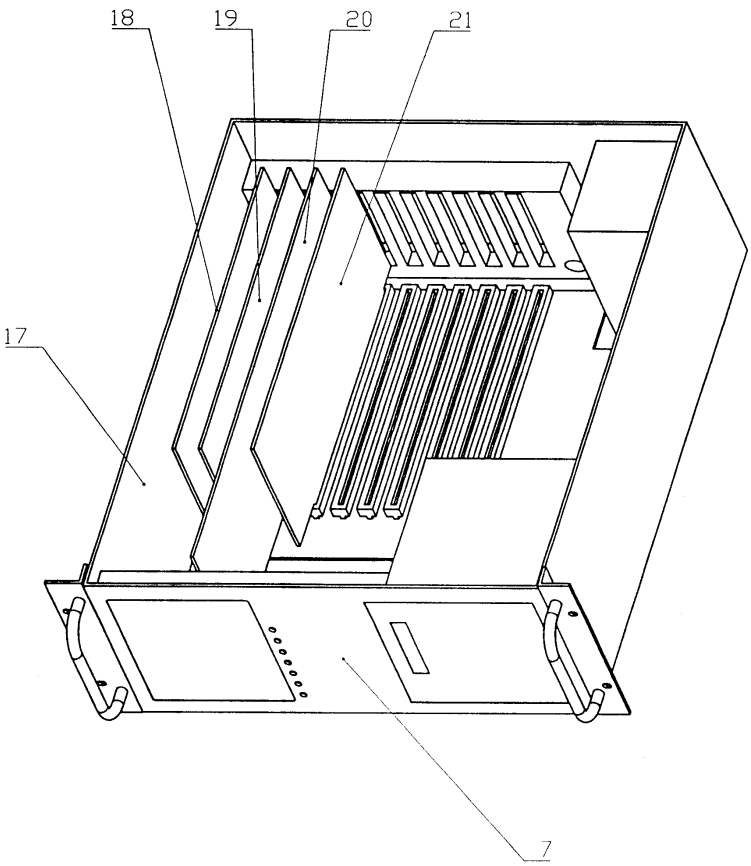

Fig. 5

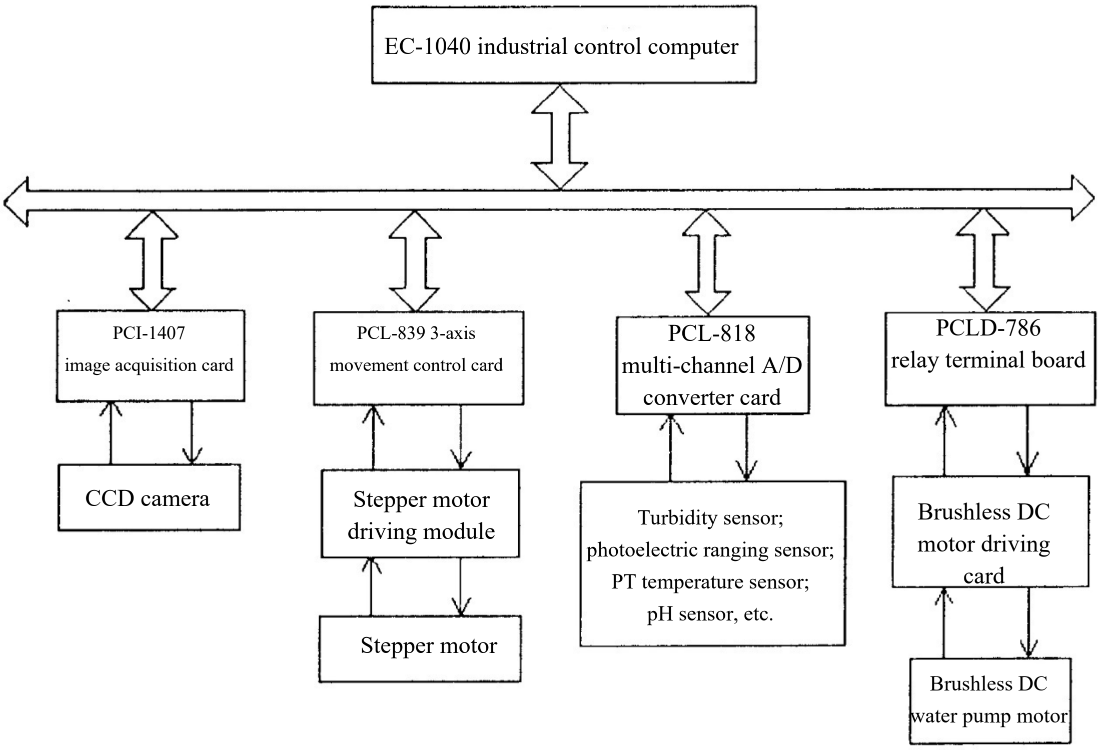
EC-1040 industrial control computer
PCI-1407
image acquisition card
PCL-839 3-axis
movement control card
PCL-818
multi-channel A/D
converter card
PCLD-786
relay terminal board
CCD camera
Stepper motor
driving module
Stepper motor
Turbidity sensor;
photoelectric ranging sensor;
PT temperature sensor;
pH sensor, etc.
Brushless DC
motor driving
card
Brushless DC
water pump motor

Fig. 6

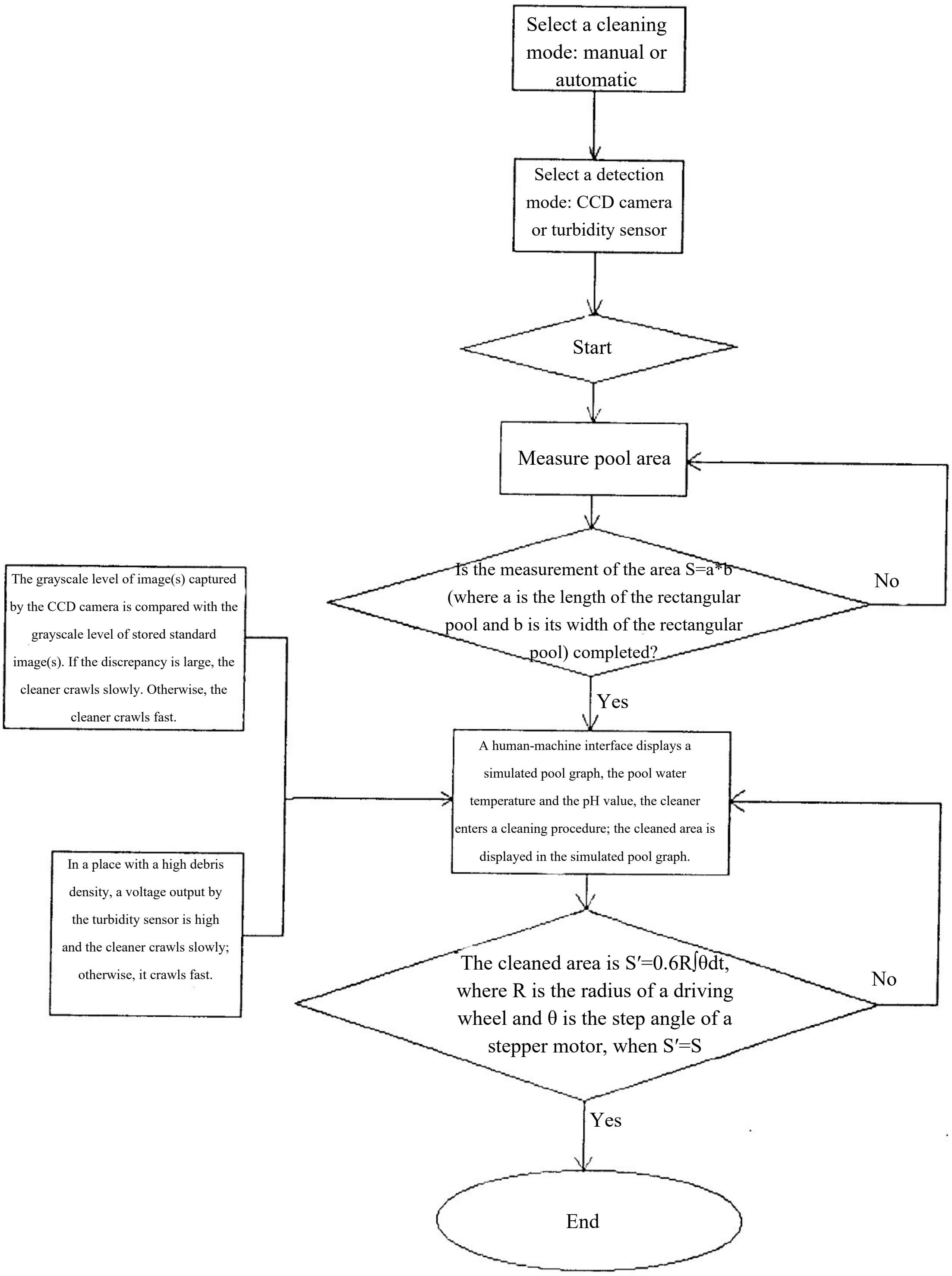
Select a cleaning mode: manual or automatic
Select a detection mode: CCD camera or turbidity sensor
Start
Measure pool area
Is the measurement of the area S=a*b (where a is the length of the rectangular pool and b is its width of the rectangular pool) completed?
No
Yes
The grayscale level of image(s) captured by the CCD camera is compared with the grayscale level of stored standard image(s). If the discrepancy is large, the cleaner crawls slowly. Otherwise, the cleaner crawls fast.
A human-machine interface displays a simulated pool graph, the pool water temperature and the pH value, the cleaner enters a cleaning procedure; the cleaned area is displayed in the simulated pool graph.
In a place with a high debris density, a voltage output by the turbidity sensor is high and the cleaner crawls slowly; otherwise, it crawls fast.
The cleaned area is S′=0.6R∫θdt, where R is the radius of a driving wheel and θ is the step angle of a stepper motor, when S′=S
No
Yes
End

Fig. 7

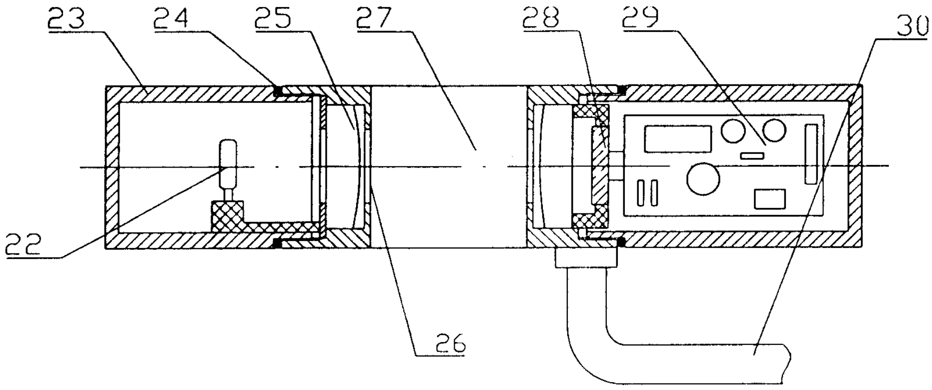
23
24
25
27
28
29
30
22
26

Fig. 8

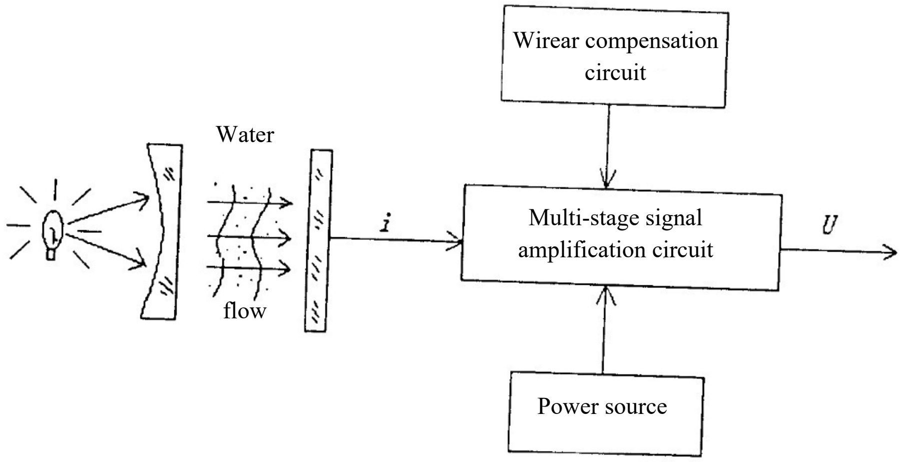
Wirear compensation circuit
Water
flow
i
Multi-stage signal amplification circuit
U
Power source

Fig. 9

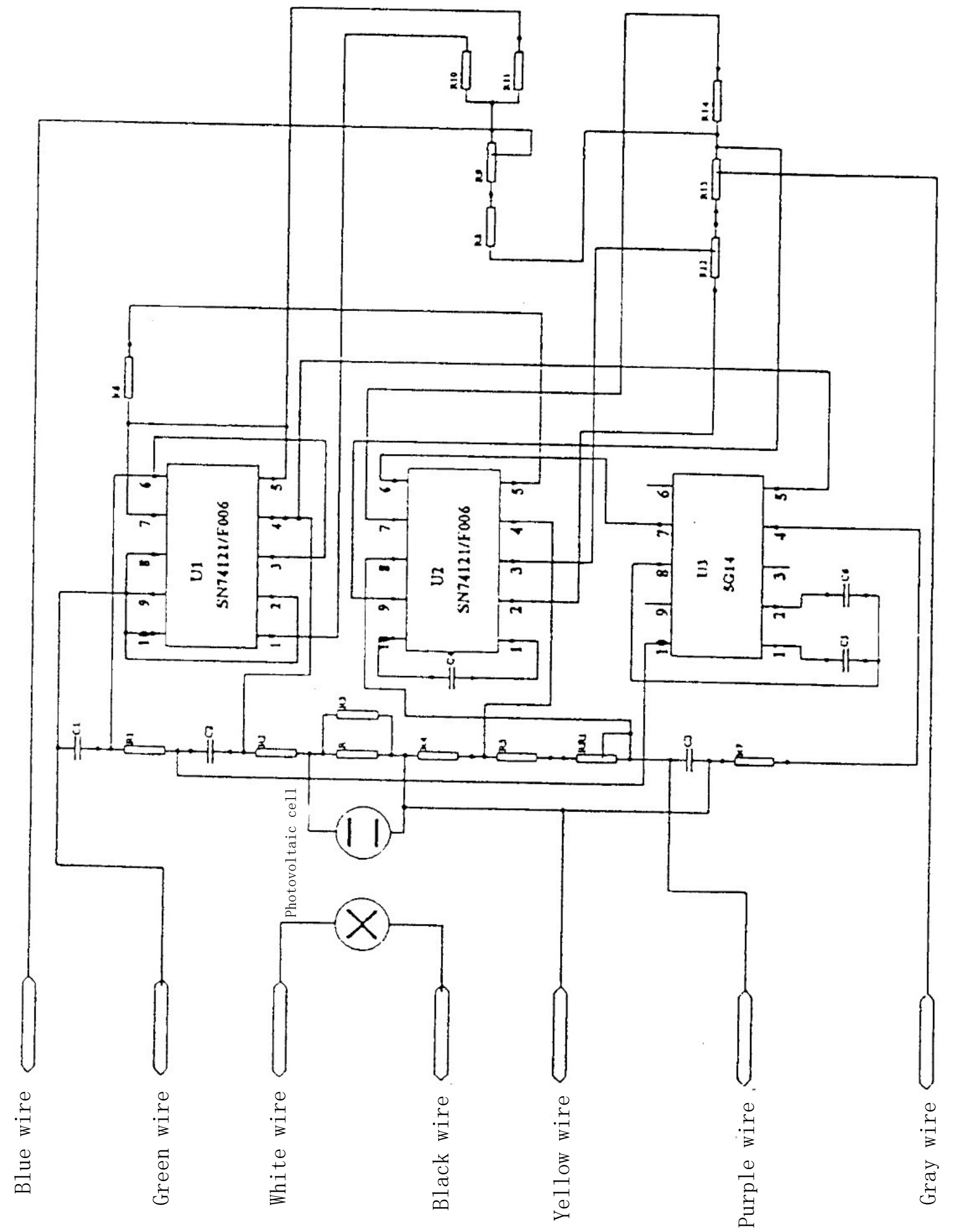
U1
SN74121/F006
U2
SN74121/F006
U3
5G14
Photovoltaic cell
Blue wire
Green wire
White wire
Black wire
Yellow wire
Purple wire
Gray wire

Fig. 10

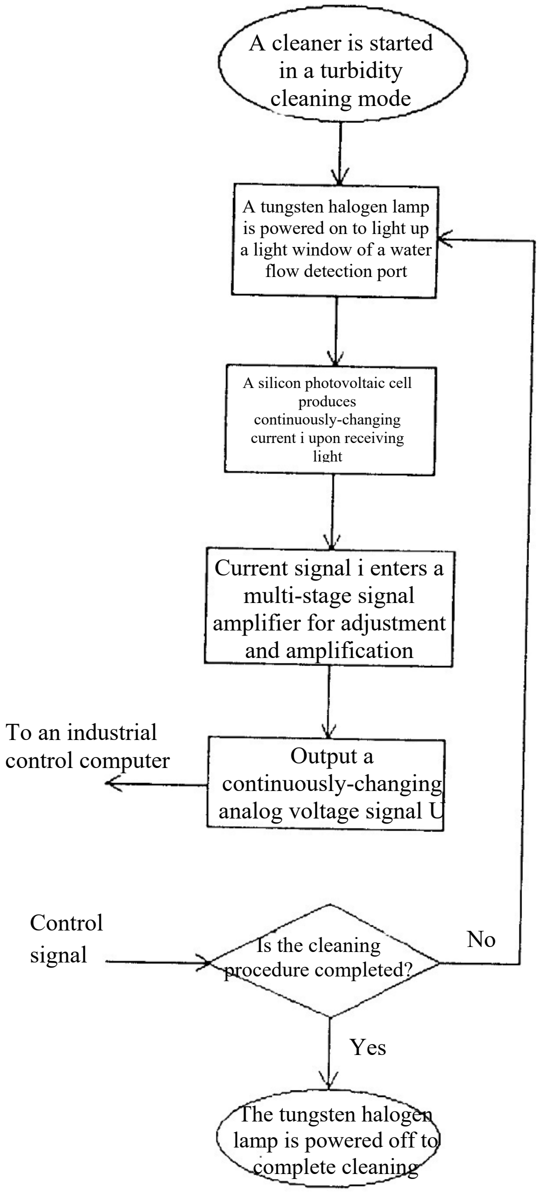
A cleaner is started in a turbidity cleaning mode
A tungsten halogen lamp is powered on to light up a light window of a water flow detection port
A silicon photovoltaic cell produces continuously-changing current i upon receiving light
Current signal i enters a multi-stage signal amplifier for adjustment and amplification
To an industrial control computer
Output a continuously-changing analog voltage signal U
Control signal
Is the cleaning procedure completed?
No
Yes
The tungsten halogen lamp is powered off to complete cleaning

Fig. 11

[19] 中华人民共和国国家知识产权局

[51] Int. Cl[7]
E04H 4/16

[12] 发明专利申请公开说明书

[21] 申请号 03116560.5

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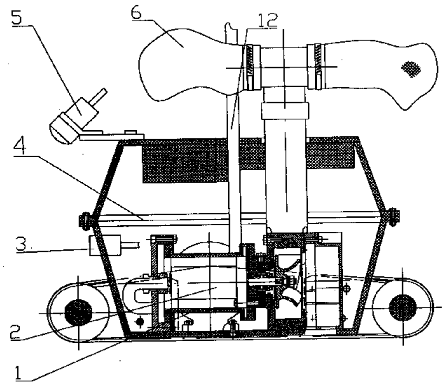
[54] 发明名称 具备污垢判别能力的水池清洗器

[57] 摘要

本发明涉及一种具备污垢判别能力的水池清洗器，可用于专业或经营性游泳场馆以及有类似需求的蓄水池，由电机密封式罩壳、无刷直流水泵电机、红外测距传感器、箱体、水流循环出口及过滤袋、工业控制计算机及相关软件、PT 电阻池水温度传感器和池水水质 pH 值传感器、履带式爬行机构、滚刷，组合电缆、插头组件、混合式步进电机组成，其特点在于，在箱体上置有污垢判别装置。本发明的优点是采用了智能化自适应技术加以计算机控制和交直流低压驱动，能根据池底污垢的不同分布状况选择相应的清洗力度，本发明结构简单，通用性强，可靠性高。



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1. 一种具备污垢判别能力的水池清洗器，由电机密封式罩壳（1）、无刷直流水泵电机（2）、红外测距传感器（3）、箱体（4）、水流循环出口及过滤袋（6）、工业控制计算机（7）及相关软件、PT 电阻池水温度传感器（8）和池水水质 PH 值传感器（9）、履带式爬行机构（10）、滚刷（11），组合电缆（12）、插头组件（14）、混合式步进电机（15）组成，其特征在于，在箱体（4）上置有污垢判别装置。

2. 根据权利要求 1 所述的具备污垢判别能力的水池清洗器，其特征在于，所述的污垢判别装置可以是电荷耦合 CCD 摄像器（5）或者是专用混浊度传感器（13）及相关软件。

3. 根据权利要求 1 所述的具备污垢判别能力的水池清洗器，其特征在于，所述的工业控制计算机（7）包括人机界面（16）、箱体（17）、三轴步进电机控制卡（18）、多通道 A/D 转换卡（19）、继电器端子板（20），图像采集卡（21），三轴步进电机控制卡（18）与混合式步进电机（15）连接，多通道 A/D 转换卡（19）分别与红外测距传感器（3）、PT 电阻池水温度传感器（8）和池水水质 PH 值传感器（9）连接，继电器端子板（20）与无刷直流水泵电机（2）连接，图像采集卡（21）与电荷耦合 CCD 摄像器（5）连接。

4. 根据权利要求 1、2 所述的具备污垢判别能力的水池清洗器，其特征在于，所述的专用混浊度传感器（13）由卤钨灯光源（22）、组合壳体（23）、密封圈（24）、光学透镜（25）、保护窗（26）、水流检测口（27）、硅光电池板（28）、多级信号放大电路板（29）、电缆（30）组成，卤钨灯光源（22）置于组合壳体（23）的中间，组合壳体（23）的一端置有保护窗（26），贴近保护窗（26）置有光学透镜（25），卤钨灯光源（22）与光学透镜（25）置于同一中心线上，密封圈（24）置于卤钨灯光源（22）和光学透镜（25）的中间，硅光电池板（28）、多级信号放大电路板（29）置于水流检测口（27）的另一边，通过插口分别与电缆（30）连接。

5. 根据权利要求 1、2、4 所述的具备污垢判别能力的水池清洗器，其特征在于，

所述多级信号放大电路板（29）由三个放大器 U1-U3、六个电容 C1-C6、数个电阻 R1-R14 组成，蓝色线经过 R8、R9、R10、R11 电阻网络提供＋6V 正极性电源，灰色线通过 R12、R13、R14 电阻网络提供－6V 正极性电源，绿色线与黄色线之间连接一个调零电阻 R0，光电池与 R、R3 连接，绿色线连接 R1、C1、R2、C2，同时连接 U1，U2 与 R4、R5、RR 连接，同时与 C4 连接，U3 与 R1、R7、C3 连接，同时与 C5、C6 连接，C3 与紫色线连接。

具备污垢判别能力的水池清洗器

技术领域

本发明涉及一种具备污垢判别能力的水池清洗器，可用于专业或经营性游泳场馆以及有类似需求的蓄水池，属于智能化电动器具技术领域。

背景技术

水池池底及池壁受水中各种杂质和杂物的侵蚀、污染、沉淀，需要定期清洗，以游泳池为例，传统的方法是人工操作，利用附带水泵吸管的排刷清洗头来回拖动洗刷，将污垢和池水一起抽出，劳动强度大，效率低，水资源浪费严重，国外近年来开发的水池清洗器， 运用单片机控制，可自动检测泳池面积，自动设置清洗时间及运行模式，但由于污垢分布是不均匀的，如果单纯以泳池的面积为依据设定时间去控制清洗器的整个工作过程，在大部分作业时间内，清洗所占比例不高，清洗效率不高。

发明内容

本发明的目的是提供一种针对不同程度的污垢分布，施加不同力度的清洗要求的具备污垢判别能力的水池清洗器。

为实现以上目的，本发明的技术方案是提供一种具备污垢判别能力的水池清洗器，由电机密封式罩壳、无刷直流水泵电机、红外测距传感器、箱体、水流循环出口及过滤袋、工业控制计算机及相关软件、PT 电阻池水温度传感器和池水水质 PH 值传感器、履带式爬行机构、滚刷、组合电缆、插头组件、混合式步进电机组成，其特点在于，在箱体上置有污垢判别装置。

所述的污垢判别装置可以是电荷耦合 CCD 摄像器或者是专用混浊度传感器及相关软件。

所述的工业控制计算机包括人机界面、箱体、三轴步进电机控制卡、多通道 A/D 转换卡、继电器端子板，图像采集卡，三轴步进电机控制卡与混合式步进发机连接，多通道 A/D 转换卡分别与红外测距传感器、PT 电阻池水温度传感器和池水水质 PH 值传感器连接，继电器端子板与无刷直流水泵电机连接，图像采集

卡与电荷耦合 CCD 摄像器连接。

本发明的优点是采用了智能化自适应技术加以计算机控制和交直流低压驱动，能根据池底污垢的不同分布状况选择相应的清洗力度，本发明结构简单，通用性强，可靠性高。

附图说明

图 1 为装有电荷耦合 CCD 摄像器的具备污垢判别能力的水池清洗器结构示意图；

图 2 为具备污垢判别能力的水池清洗器俯视图；

图 3 为装有专用混浊度传感器的具备污垢判别能力的水池清洗器结构示意图；

图 4 为工业控制计算机人机界面显示图；

图 5 为工业控制计算机结构图；

图 6 为具备污垢判别能力的水池清洗器与工业控制计算机连接方框图；

图 7 为控制软件流程图；

图 8 为专用混浊度传感器结构示意图；

图 9 为专用混浊度传感器测试原理图；

图 10 为多级信号放大电路图；

图 11 为专用混浊度传感器判别污垢的方法流程图。

具体实施方式

以下结合附图和两个实施例对本发明作进一步说明。

实施例 1：

以装有电荷耦合 CCD 摄像器的具备污垢判别能力的水池清洗器为例。

本发明采用电荷耦合 CCD 摄像器在清洗器工作过程中，不断摄取清洗器爬行方向正前下方待清洗部位的图像，并将其通过 A/D 转换形成最多可达 256 阶的灰度等级且与事先存储的池底标准图像信息不断进行比较，最后经过计算机系统处理去控制驱动清洗器爬行的速度，以达到清洗器能针对污垢分布的不同施加不同清洗力度的目的。

如图 1、2 所示，为装有电荷耦合 CCD 摄像器的具备污垢判别能力的水池清

洗器结构示意图，由电机密封式罩壳 1、无刷直流水泵电机 2、红外测距传感器 3、箱体 4、电荷耦合 CCD 摄像器 5、水流循环出口及过滤袋 6、工业控制计算机 7 及相关软件、PT 电阻池水温度传感器 8、池水水质 PH 值传感器 9、履带式爬行机构 10、滚刷 11，可调试手柄 12、插头组件 14、混合式步进电机 15 组成，电机密封式罩壳 1 罩在无刷直流水泵电机 2 上，电机密封式罩壳 1 两侧分别装有一台混合式步进电机 15，箱体 4 的前侧装有红外传测距感器 3，箱体 4 的前上端装有电荷耦合 CCD 摄像器 5，PT 电阻池水温度传感器 8 和池水水质 PH 值传感器 9 装在箱体 4 的下面，上面与水流循环出口及过滤袋 6 连接，履带式爬行机构 10 装在箱体 4 的前后端，两侧装上滚刷 11，组合电缆 12 装在箱体 4 的当中，电源箱供给水池清洗器和工业控制计算机 7 的电源，工业控制计算机 7 通过组合电缆 12 连接插头组件 14 与水池清洗器连接。

如图 4 所示，为工业控制计算机人机界面显示图，面板图的中间显示待清洗水池的面积，浅蓝色表示已清洗的面积，深蓝色表示还未清洗的面积，能一目了然清洗器工作的状况，面板图的左面设置自动和手动开关，右面设置开始、停止和继续开关，上面能显示水温、已清洗的时间和池水 PH 值。

如图 5 所示，为工业控制计算机结构图，由人机界面 16、箱体 17、三轴步进电机控制卡 18、多通道 A/D 转换卡 19、继电器端子板 20，图像采集卡 21 组成。

如图 6 所示，为具由污垢判别能力的水池清洗器与工业控制计算机连接方框图，三轴步进电机控制卡 18 与混合式步进电机 15 连接，多通道 A/D 转换卡 19 分别与红外测距传感器 3、PT 电阻池水温度传感器 8 和池水水质 PH 值传感器 9 连接，继电器端子板 20 与无刷直流水泵电机 2 连接，图像采集卡 21 与电荷耦合 CCD 摄像器 5 连接。

清洗作业时，置于清洗器前端的电荷耦合 CCD 摄像器 5 先选择池底清洁而的图像作为原始标准图像存储于工业控制计算机 7 中，清洗作业时电荷耦合 CCD 摄像器 5 摄取位于清洗器爬行方向正前下方待清洗部位的图像，该视频信号通过高速图像采集卡 21 实施 A/D 转换，配合相应的图像处理软件与存储在工业控制计算机 7 的池底原始标准图像进行比较，当池底的沉淀物多时，实时摄取的图像

灰阶等级与原始标准图像的灰阶等级相差大，比较输出的电压高，反之，输出的电压低。该电压信号被送至工业控制计算机 7 中由相关软件进行处理，处理后输出的脉冲信号指令经继电器端子板 20 分别去控制清洗器左右两台混合式步进电机 15 的驱动，清洗器爬行速度的快慢间接反映了清洗力度的大小，同时配合红外测距传感器 3，可实现清洗器的前进、后退或左右转向。

现选择矩形标准游泳池为例，结合图 7 的控制软件流程图来说明具备自适应清洗能力的水池清洗器的工作方式和清洗程序。

通电选择自适应清洗能力的清洗模式，清洗器开始工作，首先进行水池面积测量，水池面积为 S=a×b, a 为矩形水池的长，b 为矩形水池的宽，测量完成，同时 PT 电阻池水温度传感器 8 和池水水质 PH 值传感器 9 测量水温和池水水质 PH 值，人机界面显示水池面积模拟图形以及水温、池水水质 PH 值，清洗器进入清洗程序，

电荷耦合 CCD 摄像器 5 在清洗时不断摄取位于清洗器爬行方向正前下方待清洗部位的图像，该视频信号通过高速图像采集卡 21 实施 A/D 转换及工业计算机 7 和相关软件进行处理后，再经继电器端子板 20 分别去控制清洗器左右两台混合式步进电机 15 的转速，以实现自适应清洗，即不同的清洗力度对应不同的污垢分布。清洗器爬行接近池壁时，红外测距传感器 3 发出开关信号，在满足清洗器转弯半径的条件下以左右履带轮的不同配合方式实现 180° 左传或右转，再进行反向清洗，依此类推，直到整个水池清洗完毕。

水池面积模拟图形中不断显示已清洗的面积及清洗时间，已清洗面积 $S'=0.6R\int\theta dt$，其中 R 为驱动带轮的半径，θ 为步进电机的步距角，当水池面积模拟图形全部变为浅蓝色时，清洗器工作结束。

实施例 2：

以装有专用混浊度传感器的具备污垢判别能力的水池清洗器为例。

本实施例采用专用混浊度传感器，把清洗器在作业过程中，前端滚刷的擦洗和水泵吸口对污垢联合作用所引出的悬浮状水流作为判别对象，即时检测清洗器在此状态下形成的水流水质的混浊度，利用光电池的感光原理，将水流的混浊度转换成电压信号，并送至计算机控制系统处理，去控制清洗器的爬行速度，在水

质混浊的地方清洗器爬行得慢一些，以此达到针对不同程度的污垢，施加不同清洗力度的要求。

如图 2、3 所示，为装有专用混浊度传感器的具备污垢判别能力的水池清洗器结构示意图，由电机密封式罩壳 1、无刷直流水泵电机 2、红外测距传感器 3、箱体 4、水流循环出口及过滤袋 6、工业控制计算机 7 及相关软件、PT 电阻池水温度传感器 8、池水水质 PH 值传感器 9、履带式爬行机构 10、滚刷 11、组合电缆 12、专用混浊度传感器 13、插头组件 14、混合式步进电机 15 组成，在无刷直流水泵电机 2 的下面吸口的前端装上专用混浊度传感器 13，其他部件连接关系不变。

如图 8 所示，为专用混浊度传感器结构示意图，专用混浊度传感器 13 由卤钨灯光源 22、组合壳体 23、密封圈 24、光学透镜 25、保护窗 26、水流检测口 27、硅光电池板 28、多级信号放大电路板 29、电缆 30 组成，卤钨灯光源 22 置于组合壳体 23 的中间，组合壳体 23 的一端置有保护窗 26，贴近保护窗 26 置有光学透镜 25，卤钨灯光源 22 与光学透镜 25 置于同一中心线上，密封圈 24 置于卤钨灯光源 22 和光学透镜 25 的中间，硅光电池板 28、多级信号放大电路板 29 置于水流检测口 27 的另一边，通过插口分别与电缆 30 连接。

图 9 为专用混浊度传感器测试原理图，卤钨灯光源 22 发出的散射光经光学透镜 25 折射成一组平行光束，该光束透过保护窗 26 通过水流检测口 27 正对着的硅光电池板 28，中间的水介质则是被检测的对象，硅光电池板 28 可将光信号转换为电流信号，当水流中的悬浮物多时，混浊度大，到达硅光电池板 28 的光电信号强度弱，输出的电流小，反之，输出的电流大，电流信号再经过多级信号放大电路板 29 的调整放大以模拟电压信号的形式输出并送至工业控制计算机 7 处理。

为了保证水泵吸口的水流都流经专用混浊度传感器 13 的检测口，专用混浊度传感器 13 安装在水泵吸口的前端。保护窗 26 采用高硬度石英玻璃能抵御水流中细小沙石对其的磨损，长时间维持光通量的稳定性。

如图 10 所示，为多级信号放大电路图，多级信号放大电路板 29 由三个放大器 U1-U3、六个电容 C1-C6、数个电阻 R1-R14 组成，蓝色线经过 R8、R9、R10、R11 电阻网络提供＋6V 正极性电源，灰色线通过 R12、R13、R14 电阻网络提供

—6V 正极性电源，绿色线与黄色线之间连接一个调零电阻 R0，以实现对专用混浊度传感器 13 信号输出范围的标定，光电池与 R、R3 连接，绿色线连接 R1、C1、R2、C2，同时连接 U1，U2 与 R4、R5、RR 连接，同时与 C4 连接，U3 与 R1、R7、C3 连接，同时与 C5、C6 连接，C3 与紫色线连接。

图 11 为专用混浊度传感器判别污垢的方法流程图，开关电源的±6V 电压接在专用混浊度传感器 13 的白色线（＋）和黑色线（－）两端，使得高亮度卤钨灯光源 22 点亮，提供专用混浊度传感器光学电路需要的光源。光线经过光学透镜 25 折射，聚焦在硅光电池板 28 上，硅光电池板 28 将光电信号转换成电信号，由取样电阻 R 采集此电信号，在信号放大电路中，R1、C1、R2、C2 组成阻容滤波，R3、R6 为分流电阻，C4、C5、C6 为 U1、U2、U3 的滤波电容，平衡电阻 R4、R5、RR 对放大器的信号进行线性补偿，信号经过 U1、U2 的放大以及 U3 对信号的比较放大后，再经过 R7、C3 滤波，由紫色线输出信号到工业控制计算机 7 的多通道 A/D 转换卡 19，计算机可以根据专用混浊度传感器 13 的信号强弱反映出水池中水的不同清洁度，输出相应的脉冲来调节混合式步进电机 15 的转速，从而提高清洗的工作效率，卤钨灯光源 22 断电表示测量结束。

在工作前，先要对多级信号放大电路板 29 中的 R0，即对专用混浊度传感器 13 的测量范围进行标定，然后根据信号输出范围，通过计算机软件的处理再去控制清洗过程。

清洗工作时，经滚刷擦洗过的污垢与水混合组成的悬浮液受水泵作用必定要流进水泵吸口，此时安装在水泵吸口处的专用混浊度传感器 13 将水流的不同混浊度转换成变化着的电压信号，该电压信号经过 A/D 转换卡 19 转换筛选后，送至工业控制计算机 7 由相关软件进行处理，处理后输出的脉冲信号或“开、停”指令经继电器端子板 20 去控制无刷直流水泵电机 2 的驱动，水流的混浊度高，清洗器的爬行速度变慢，清洗力度加大，反之则清洗力度减小，同时配合红外测距转向光电传感器 3 可实现清洗器的前进、后退或左右转向。

选择矩形标准游泳池为例，结合图 7 的控制软件流程图来说明具备污垢判别能力的水池清洗器的工作方式和清洗程序。

选择自动清洗模式，清洗器通电开始工作，首先进行水池面积测量，水池面

积为 $S=a\times b$, a 为矩形水池的长，b 为矩形水池的宽，测量完成，同时 PT 电阻池水温度传感器 8 和池水水质 PH 值传感器 9 测量水温和池水水质 PH 值，人机界面显示水池面积模拟图形以及水温、池水水质 PH 值，清洗器进入清洗程序，专用混浊度传感器 13 不断对即将进入水泵吸口的水进行检测，混浊度的变化致使专用混浊度传感器 13 输出的电压发生变化，该电压信号被送至 A/D 转换卡 19 转换过滤成数字脉冲信号，再经继电器端子板 20 送至驱动模块放大后去控制无刷直流水泵电机 2 的转速，以达到不同的清洗力度，清洗器爬行接近池壁时，红外测距传感器 3 发出开关信号，在满足清洗器转弯半径的条件下以左右履带轮的不同配合方式实现 180° 左传或右转，再进行反向清洗，依此类推，直到整个水池清洗完毕，在水池面积模拟图形中不断显示已清洗的面积及清洗时间，已清洗面积 $S'=0.6R\int\theta dt$，其中 R 为驱动带轮的半径，θ 为步进电机的步距角，当模拟水池面积图形全部变为浅蓝色时，清洗器工作结束。

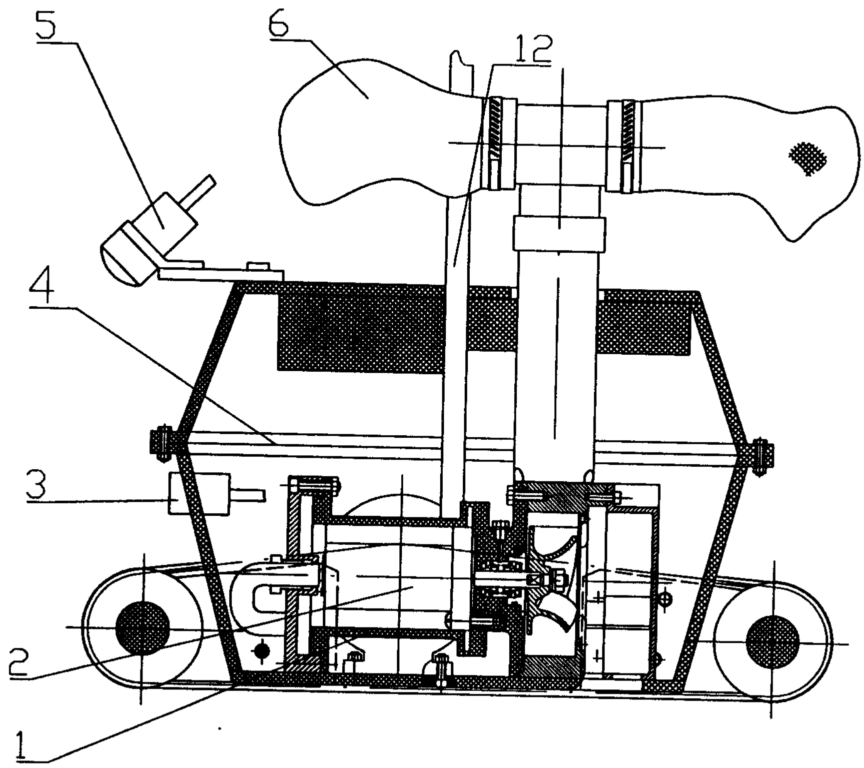

图1

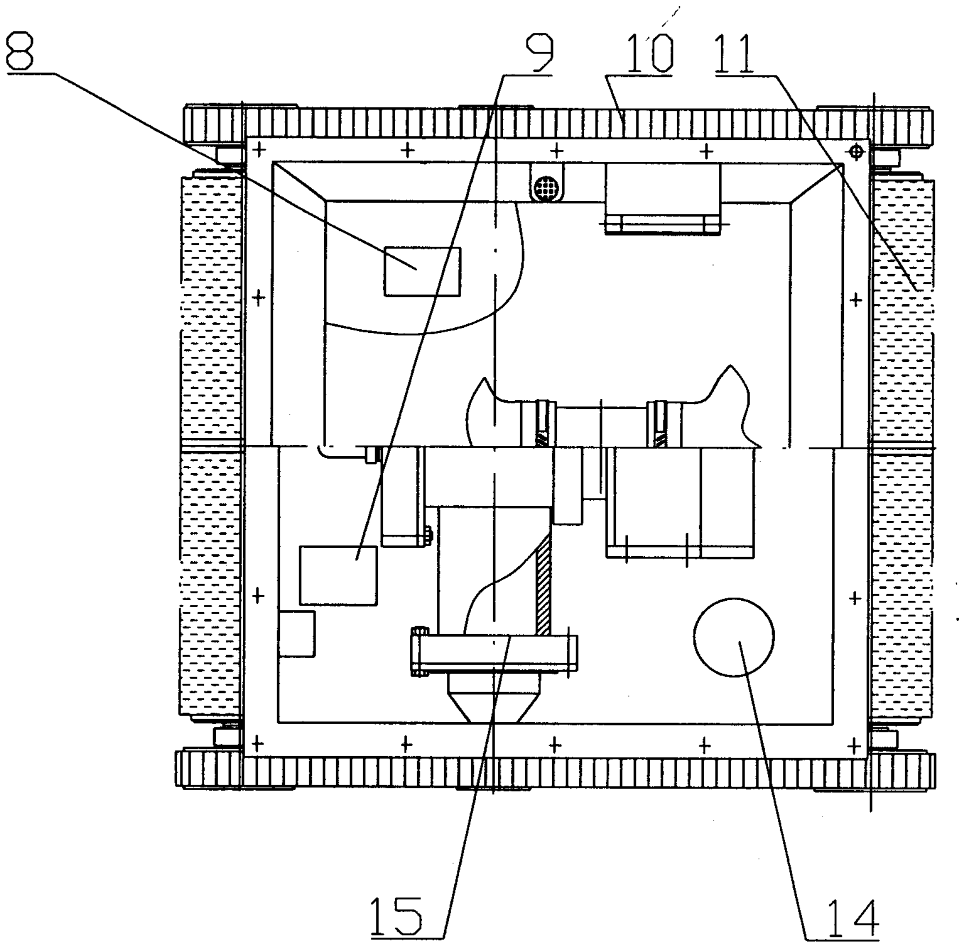

图2

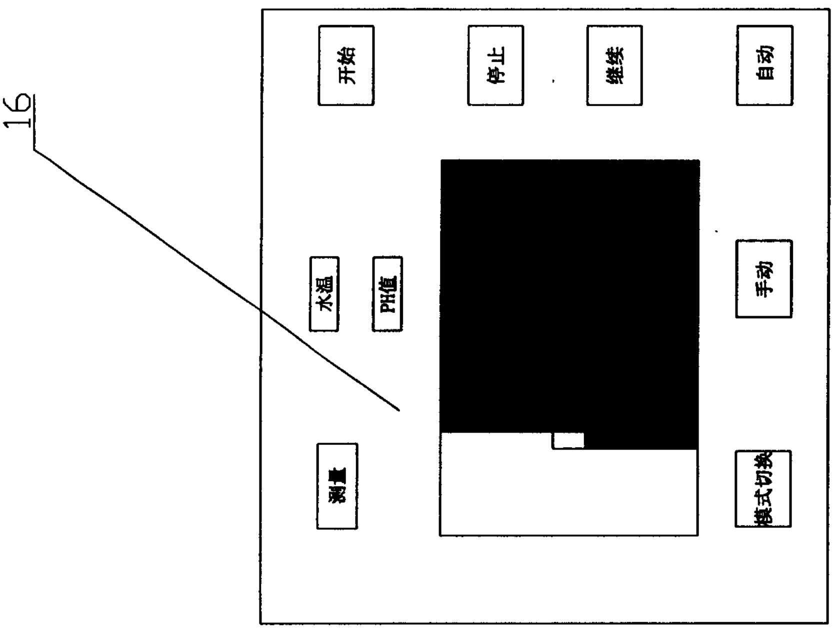

图4

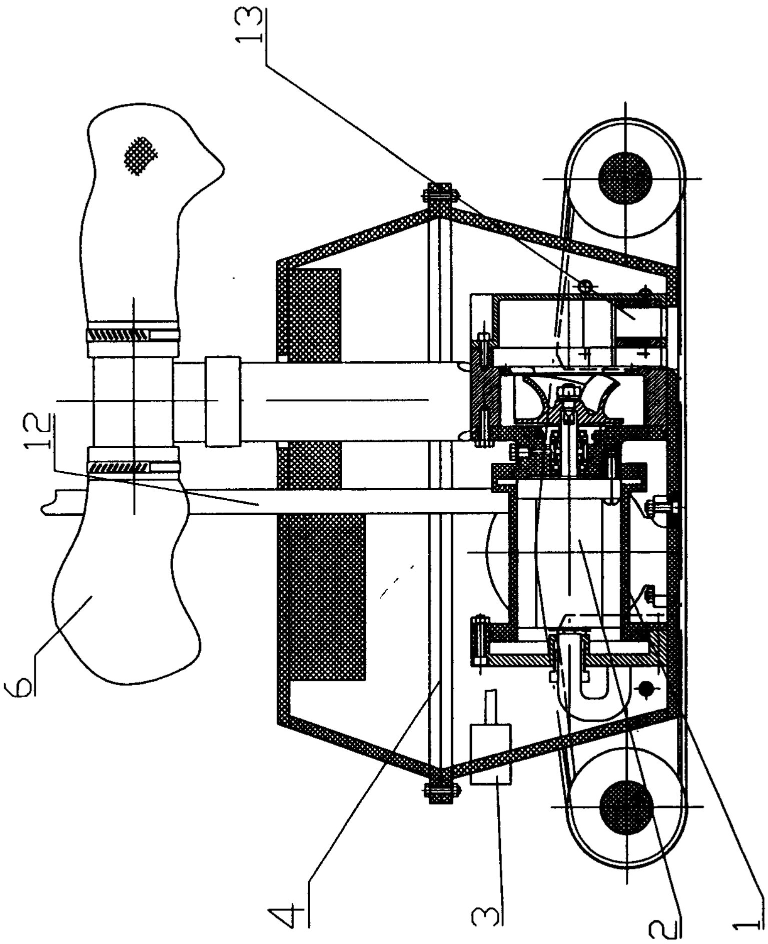

图3

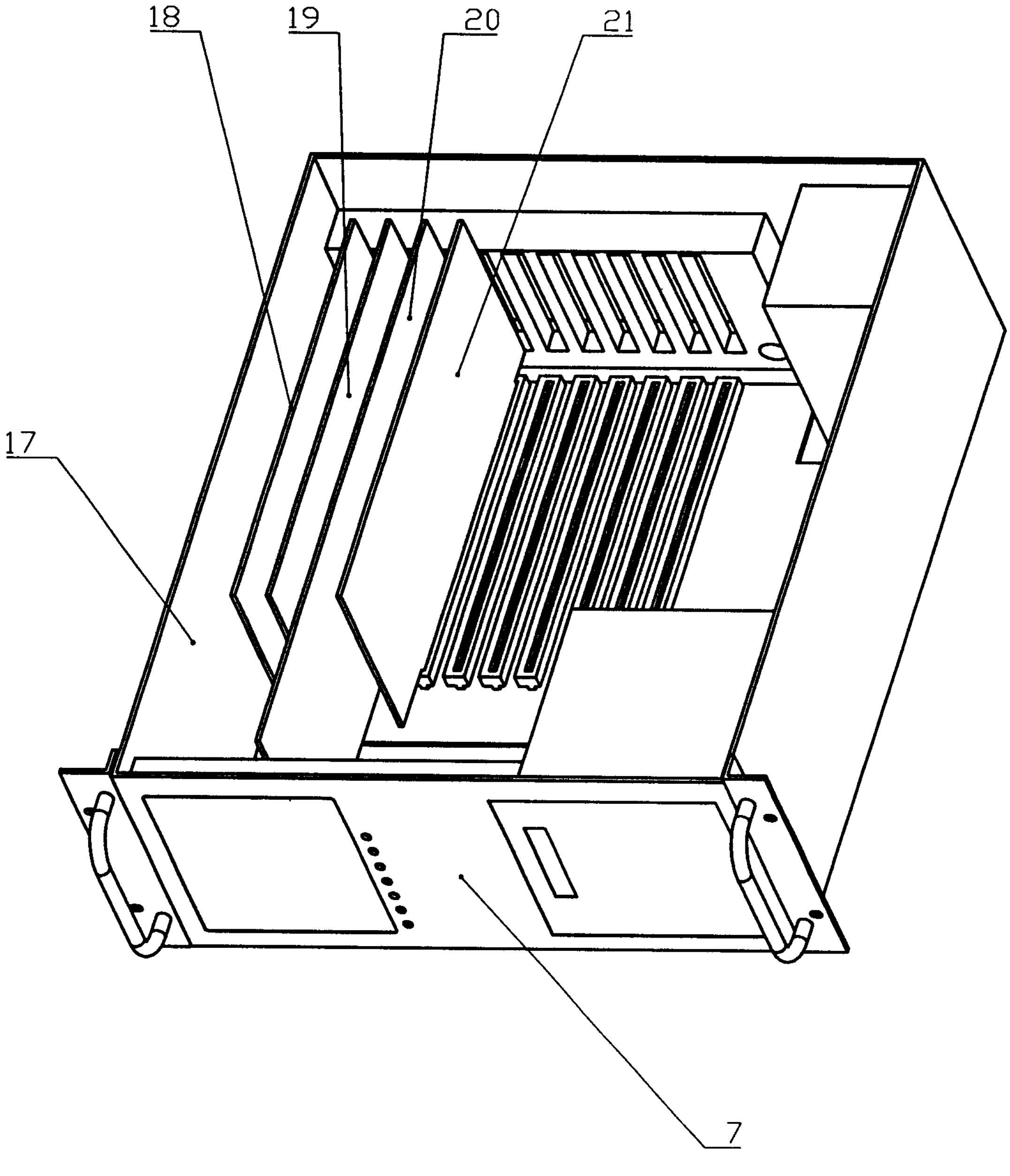

图5

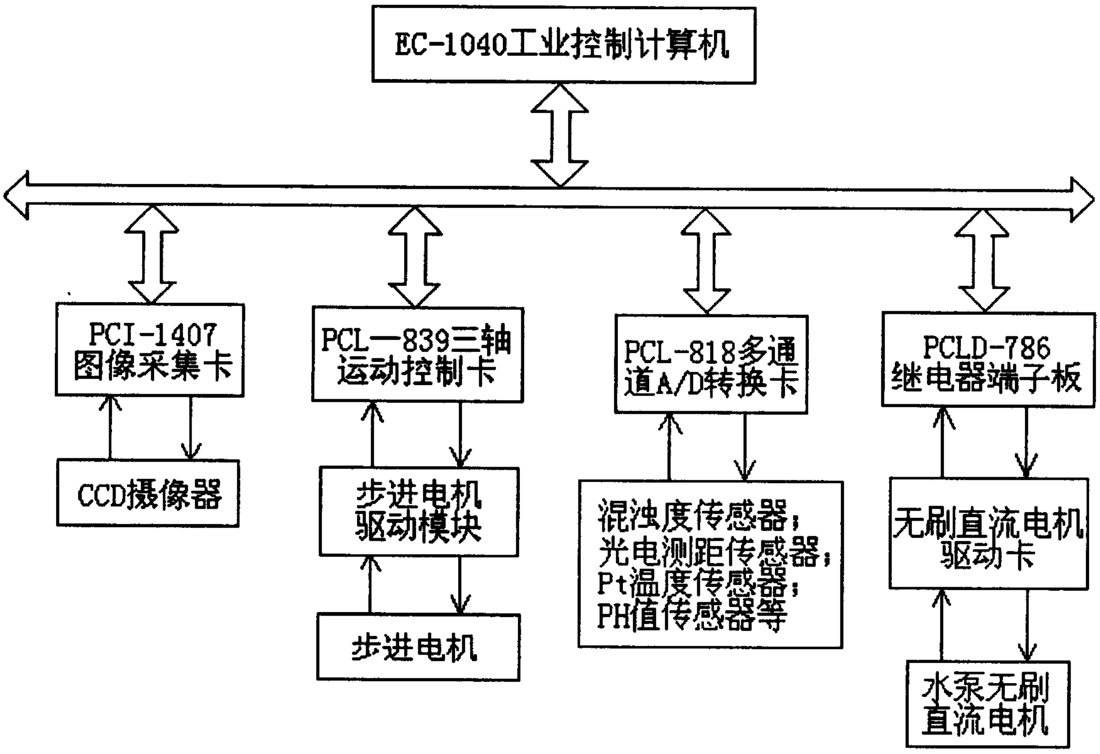
EC-1040工业控制计算机
PCI-1407
图像采集卡
CCD摄像器
PCL—839三轴
运动控制卡
步进电机
驱动模块
步进电机
PCL-818多通
道A/D转换卡
混浊度传感器;
光电测距传感器;
Pt温度传感器;
PH值传感器等
PCLD-786
继电器端子板
无刷直流电机
驱动卡
水泵无刷
直流电机

图6

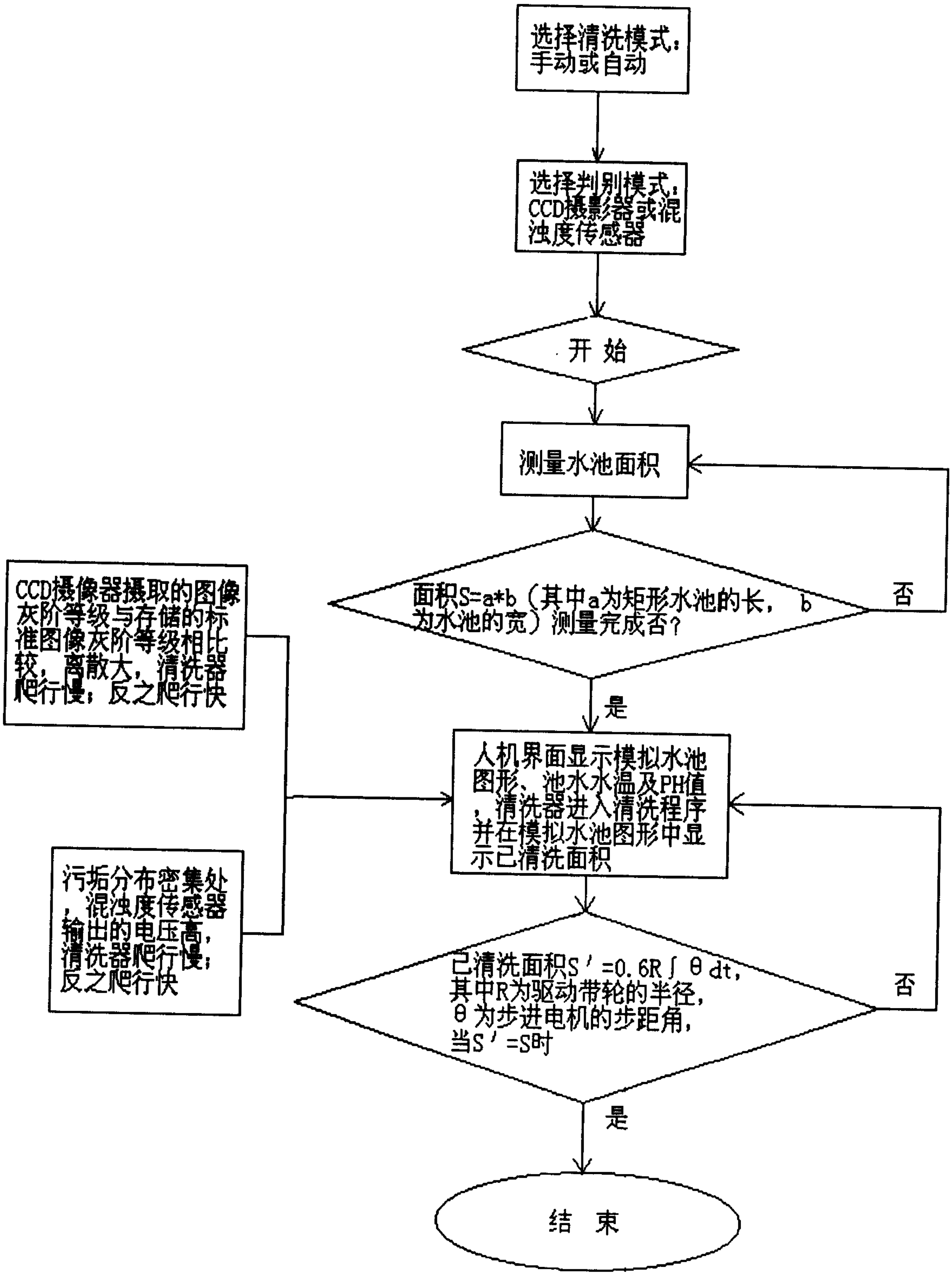
选择清洗模式：手动或自动
选择判别模式：CCD摄影器或混浊度传感器
开 始
测量水池面积
面积S=a*b（其中a为矩形水池的长，b为水池的宽）测量完成否？
否
是
CCD摄像器摄取的图像灰阶等级与存储的标准图像灰阶等级相比较，离散大，清洗器爬行慢；反之爬行快
人机界面显示模拟水池图形、池水水温及PH值，清洗器进入清洗程序并在模拟水池图形中显示已清洗面积
污垢分布密集处，混浊度传感器输出的电压高，清洗器爬行慢；反之爬行快
已清洗面积S′=0.6R∫θdt，其中R为驱动带轮的半径，θ为步进电机的步距角，当S′=S时
否
是
结 束

图 7

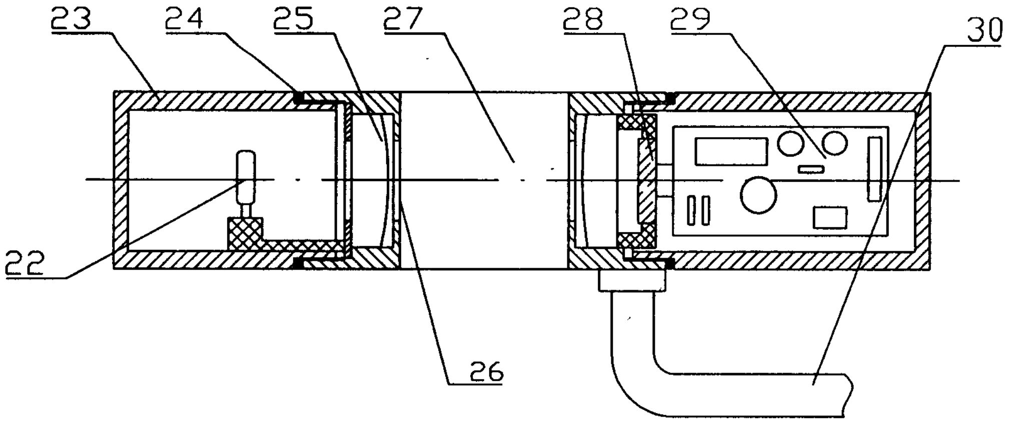

图8

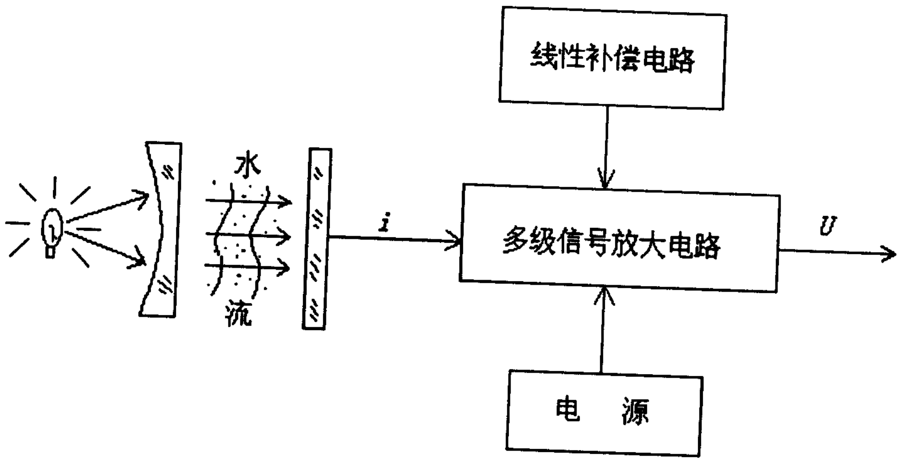

图9

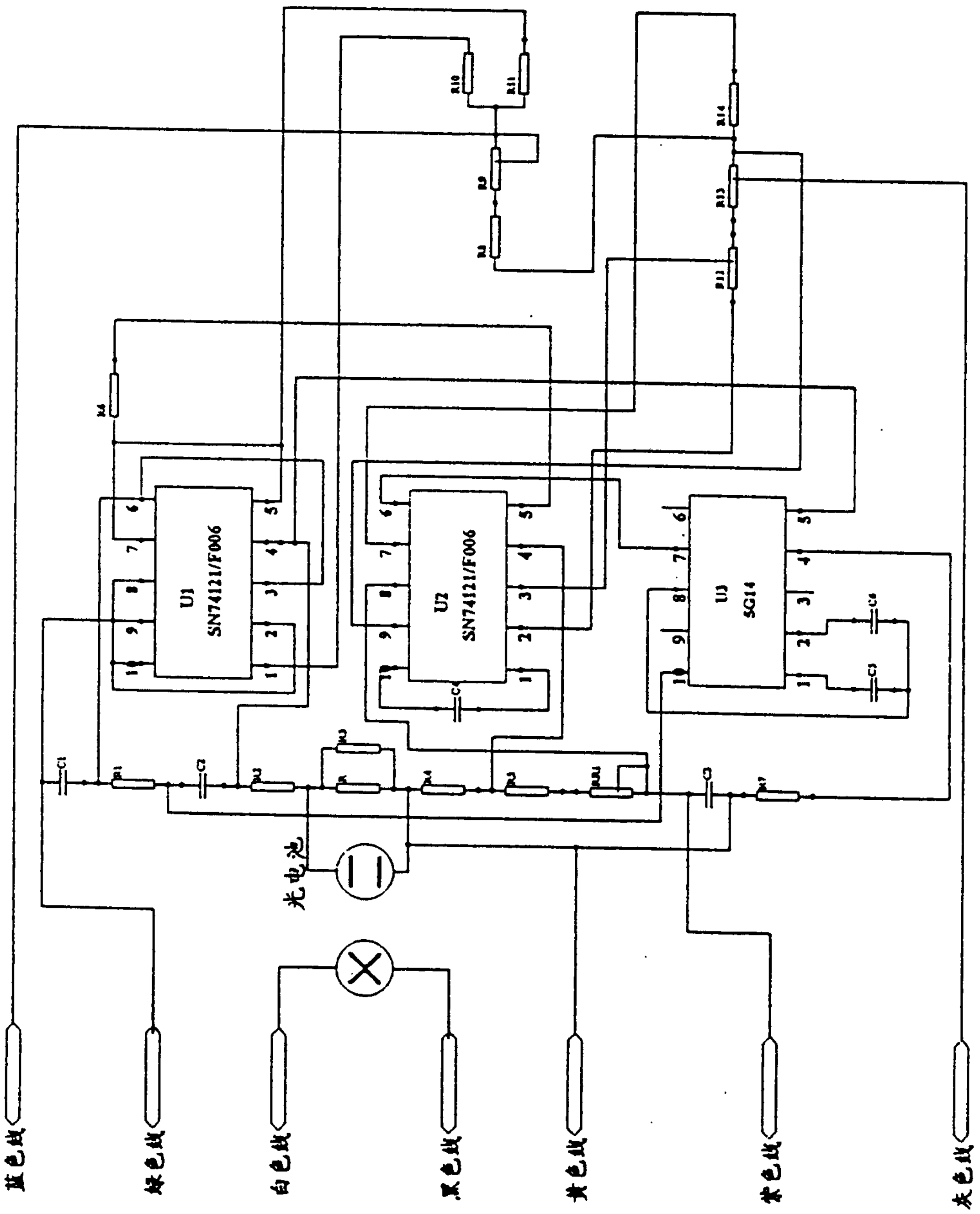
U1
SN74121/F006
U2
SN74121/F006
U3
SG14
光电池
蓝色线
绿色线
白色线
黑色线
黄色线
紫色线
灰色线

图10

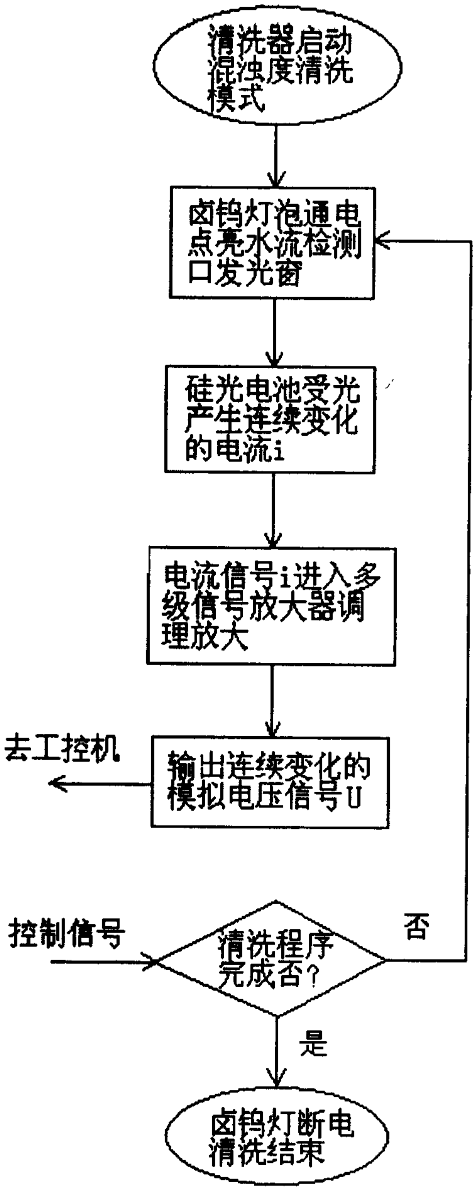
清洗器启动
混浊度清洗
模式
卤钨灯泡通电
点亮水流检测
口发光窗
硅光电池受光
产生连续变化
的电流i
电流信号i进入多
级信号放大器调
理放大
去工控机
输出连续变化的
模拟电压信号U
控制信号
清洗程序
完成否？
否
是
卤钨灯断电
清洗结束

图11