

[DESCRIPTION]

[Title of the Invention]

METAL RECOVERY SYSTEM

[Technical Field]

[0001]

The present invention relates to a metal detector.

[Background Art]

[0002]

Printed circuit boards used in the field of electronic components are configured from copper, which serves as the circuit, and resin, which serves as the substrate material. When forming an electroless plating film such as electroless copper plating on a printed circuit board, because there is a non-conductive material part on the surface of the printed circuit board to be plated, the application of a catalyst metal is required. In the catalytic process of applying the catalyst metal, the printed circuit board is treated in an alkaline catalyst metal ion solution and thereafter treated in a reducing agent solution, or treated in an acidic catalyst metal colloid solution and thereafter treated in an acid solution. Palladium is often used as the catalyst metal. The catalyst solution is replaced regularly. Valuable metals such as palladium contained in the spent catalyst solution are generally recovered using an adsorbent.

[Prior Art Documents]

[Patent Documents]

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 2013-205074

[Patent Document 2] Japanese Unexamined Patent Application Publication No. 2011-122987

[Patent Document 3] Japanese Unexamined Patent Application Publication No. 2000-107507

[Patent Document 4] Japanese Unexamined Patent Application Publication No. 2005-351784

[Patent Document 5] Japanese Patent No. 3019938

[Patent Document 6] Japanese Patent No. 3693124

[Patent Document 7] Japanese Patent No. 4410586

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0004]

The recovery of palladium from the catalyst solution is performed by passing the catalyst solution through a container filled with an adsorbent. The recovery of palladium is often performed during the catalytic process in consideration of liquid transport costs and outflow risks. When a certain amount of palladium is passed through the adsorbent, a saturation point referred to as the adsorption limit is reached, and the leakage of palladium will occur. The leaked palladium may result in a loss. The leakage can be verified by periodically sampling the catalyst solution after passing through the adsorbent and measuring the palladium concentration. Nevertheless, because the timing of palladium leakage will also differ depending on the concentration and throughput of palladium passed through the adsorbent, depending on the sampling period, it may not be possible to replace the adsorbent in time, and this may result in the loss of palladium.

[0005]

The object of this disclosed technology is to provide a technique capable of constantly detecting a substance contained in the solution.

[Means for Solving the Problems]

[0006]

In order to achieve the foregoing object, the present invention adopts the following means.

[0007]

In other words, the first mode of the present invention is a metal detector, comprising:
a cylindrical tube through which flows a solution containing a metal;
a light source that irradiates inside of the tube with light including light of a complementary color of a liquid color of the solution containing the metal under white light;
a detection part that detects light from inside the tube; and
a control unit that acquires a detection result from the detection part,
wherein the control unit determines whether a metal concentration of the metal contained in the solution is equal to or greater than a predetermined value based on the detection result.

[0008]

The disclosed mode may also be realized by a program being executed by an

information processing device. In other words, the disclosed configuration may be identified as a program for causing an information processing device to execute the processing to be executed by each of the means in the foregoing mode, or as a recording medium that can be read by an information processing device on which such program has been recorded. Moreover, the disclosed configuration may also be identified as a method of causing an information processing device to execute the processing to be executed by each of the foregoing means. The disclosed configuration may also be identified as a system including an information processing device to execute the processing to be executed by each of the foregoing means. Note that the information processing device is, for example, a computer. The computer is also referred to as a personal computer or a server.

[Effect of the Invention]

[0009]

According to the disclosed technology, it is possible to provide a technique capable of constantly detecting a substance contained in the solution.

[Brief Description of the Drawings]

[0010]

[Fig. 1]

Fig. 1 is a diagram showing a configuration example of the metal recovery system according to an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a diagram showing a configuration example of the metal detector 300.

[Fig. 3]

Fig. 3 is a diagram showing a hardware configuration example of the information processing device.

[Fig. 4]

Fig. 4 is a diagram showing an example of the operational flow of the detection of the metal by the metal detector 300.

[Fig. 5]

Fig. 5 is a diagram showing an example of the relationship (1) between the output of the illuminance sensor and the metal concentration of the solution.

[Fig. 6]

Fig. 6 is a diagram showing an example of the relationship (2) between the output of the illuminance sensor and the metal concentration of the solution.

[Best Mode for Carrying Out the Invention]

[0011]

An embodiment of the present invention is now explained with reference to the appended drawings. The configuration of this embodiment is an exemplification, and the configuration of the present invention is not limited to the specific configuration of the disclosed embodiment. In working the present invention, a specific configuration may be adopted as needed depending on the embodiment.

[0012]

[Embodiments]

The metal recovery system of this embodiment performs adsorption and recovery of a metal by passing a solution, in which a metal such as palladium to be treated has been dissolved, through an adsorbent, and using a metal detector to detect the metal such as palladium remaining in the solution after being passed through the adsorbent. The solution is, for example, a palladium catalyst solution used during the plating process. Here, while a solution in which a metal has been dissolved is used, it may also be a solution in which a substance other than metal has been dissolved.

[0013]

For example, when a palladium catalyst solution is passed through an adsorbent, the liquid color, which is a brown color or a black color under white light, becomes clear and colorless. When palladium is adsorbed by the adsorbent, the liquid color becomes colorless. The liquid color of a brown color or a black color is a result of the palladium compound (tetraammine palladium, diammine dinitrito palladium or the like). The fact that the liquid color is a brown color (orange color) under white light means that a green-blue color or a blue-green color, which is the complementary color of a brown color (orange color), has been absorbed. When the adsorbent reaches its adsorption limit and the adsorbent can no longer adsorb palladium, the concentration (leakage concentration) of palladium in the solution after passing through the adsorbent will increase. Here, the color of the solution after passing through the adsorbent will change from clear and colorless to a brown color or a black color. The metal detector can determine the concentration of palladium in the solution by detecting the amount of light that has been absorbed.

[0014]

(Configuration example)

Fig. 1 is a diagram showing a configuration example of the metal recovery system

according to an embodiment of the present invention. The metal recovery system 10 of Fig. 1 includes a first adsorption part 100, a second adsorption part 200, a metal detector 300, a first pipe 410, a second pipe 420, a third pipe 430, and a fourth pipe 440. The first adsorption part 100 is connected to the first pipe 410 and the second pipe 420. The second adsorption part 200 is connected to the third pipe 430 and the fourth pipe 440. The metal detector 300 is connected to the second pipe 420 and the third pipe 430. The solution to be treated is introduced into the first adsorption part 100 from the first pipe 410, and the metal is adsorbed by the first adsorption part 100. The solution ejected from the first adsorption part 100 is introduced into the metal detector 300 via the second pipe 420. The metal detector 300 detects the residual metal of the introduced solution. The solution ejected from the metal detector 300 is introduced into the second adsorption part 200 via the third pipe 430, and the metal is adsorbed by the second adsorption part 200. The solution ejected from the second adsorption part 200 is discharged via the fourth pipe 440. The metal is thereby removed from the solution to be treated.

[0015]

The first adsorption part 100 includes an adsorbent, and a container filled with the adsorbent. The adsorbent is, for example, resin that adsorbs the metal contained in the solution. The adsorbent recovers the metal by adsorbing the metal contained in the solution. As the adsorbent, ion exchange resin or the like may be used. Ion exchange resin may be suitably selected depending on the type of metal to be adsorbed. When the adsorbent reaches its adsorption limit, it becomes difficult for the adsorbent to adsorb the metal contained in the solution, and it becomes easier for the solution containing the metal to be discharged from an outlet. It is desirable that the adsorbent that reached its adsorption limit is replaced as soon as possible. There is no limit to the shape, size, material or the like of the container filled with the adsorbent. As the container, a glass container, a resin container, a metal container or the like may be used. The container is connected to the first pipe 410, and comprises an inlet for introducing the solution, and an outlet that is connected to the second pipe 420 and used for discharging the solution that passed through the adsorbent.

[0016]

The second adsorption part 200 is configured in the same manner as the first adsorption part 100. The container of the second adsorption part 200 filled with the adsorbent is connected to the third pipe 430, and comprises an inlet for introducing the

solution, and an outlet that is connected to the fourth pipe 440 and used for discharging the solution that passed through the adsorbent. The second adsorption part 200 adsorbs the metal, which could not be adsorbed with the first adsorption part 100, with an adsorbent.

[0017]

The metal detector 300 detects the metal remaining in the solution by irradiating the solution ejected from the first adsorption part 100 with light, and detecting the absorbed amount of the light.

[0018]

The first pipe 410, the second pipe 420, the third pipe 430, and the fourth pipe 440 are each a cylindrical tube through which the solution is passed. There is no limitation to the shape, size, material or the like of each pipe. As each pipe, a glass tube, a resin tube, a metal tube or the like may be used.

[0019]

Fig. 2 is a diagram showing a configuration example of the metal detector 300. The metal detector 300 of Fig. 2 comprises a measurement tube 310, an inlet tube 320, an outlet tube 330, a first light transmission window 340, a light source 350, a second light transmission window 360, and an illuminance sensor 370. Here, let it be assumed that the direction from left to right of Fig. 2 is the +x direction, the direction from the front to the back of Fig. 2 is the +y direction, and the direction from bottom to top of Fig. 2 is the +z direction. Moreover, here, let it be assumed that the xy plane is the horizontal plane, and the -z direction (direction from top to bottom of Fig. 2) is the vertical direction.

[0020]

The measurement tube 310 is a cylindrical straight (linear) tube. Here, the direction of the tube of the measurement tube 310 is parallel to the x-axis. The cross section of the measurement tube 310 is, for example, circular. The first light transmission window 340 is provided to one end of the measurement tube 310, and the second light transmission window 360 is provided to the other end of the measurement tube 310. The inlet tube 320 is connected to the measurement tube 310 near the first light transmission window 340. The outlet tube 330 is connected to the measurement tube 310 near the second light transmission window 360. The solution is introduced into the measurement tube 310 from the inlet tube 320, and discharged from the outlet tube 330. The solution flows through the measurement tube 310. The measurement tube 310 is irradiated with light from the light source 350 via the first light transmission

window 340. The irradiated light passes through the solution in the measurement tube 310, and is detected by the illuminance sensor 370 via the second light transmission window 360. There is no limitation to the size, material or the like of the measurement tube 310. As the measurement tube 310, a glass tube, a resin tube, a metal tube or the like may be used. The measurement tube 310 is preferably opaque to prevent light, which would interfere with the measurement, from entering.

[0021]

The inlet tube 320 is connected to the second pipe 420 and the measurement tube 310. The inlet tube 320 introduces the solution from the first adsorption part 100 into the measurement tube 310 via the second pipe 420. The inlet tube 320 is connected to the +z direction side of the measurement tube 310, and extends in the +z direction. There is no limitation to the shape, size, material or the like of the inlet tube 320. As the inlet tube 320, a glass tube, a resin tube, a metal tube or the like may be used. The inlet tube 320 is preferably opaque to prevent light, which would interfere with the measurement, from entering the measurement tube 310.

[0022]

The outlet tube 330 is connected to the measurement tube 310 and the third pipe 430. The outlet tube 330 introduces the solution from the measurement tube 310 into the second adsorption part 200 via the third pipe 430. The outlet tube 330 is connected to the +z direction side of the measurement tube 310, and extends in the +z direction. There is no limitation to the shape, size, material or the like of the outlet tube 330. As the outlet tube 330, a glass tube, a resin tube, a metal tube or the like may be used. The outlet tube 330 is preferably opaque to prevent light, which would interfere with the measurement, from entering the measurement tube 310. The position of the inlet tube 320 and the position of the outlet tube 330 may be interchanged. The cross section of the inlet tube 320 and the outlet tube 330 is, for example, circular.

[0023]

Preferably, air bubbles (gas) that interfere with the measurement are prevented from entering the measurement tube 310. As a result of the inlet tube 320 and the outlet tube 330 being connected to the measurement tube 310 in the +z direction, the air bubbles in the measurement tube 310 are discharged outside the measurement tube 310 via the inlet tube 320 and the outlet tube 330. In a state where no air bubbles (gas) can enter inside the measurement tube 310, the measurement tube 310, the inlet tube 320, and the outlet tube 330 may be oriented in any direction. In the foregoing case,

for example, the measurement tube 310 may be parallel to the z-axis. The second pipe 420 and the third pipe 430 may also be directly connected to the measurement tube 310.

[0024]

The first light transmission window 340 is a window that transmits light from the light source 350 into the measurement tube 310. The first light transmission window 340 is provided to one end of the measurement tube 310. The first light transmission window 340 is, for example, a transparent material such as sapphire glass. As the first light transmission window 340, preferably selected is a material that does not dissolve easily in a solution, or a material on which the metal in the solution does not deposit easily.

[0025]

The light source 350 irradiates the inside of the measurement tube 310 with light via the first light transmission window 340. The light source 350 is, for example, an LED (Light Emitting Diode), a laser or the like. As the light source 350, used is a light source having the wavelength of light that is absorbed by the solution when the metal is included in the solution. The light that is absorbed by the solution when the metal is included in the solution corresponds to the complementary color of the color of the solution under white light. As the light source 350, used may be, for example, a blue color LED having a wavelength of roughly 450 nm to 470 nm or an orange LED having a wavelength of roughly 600 nm to 620 nm depending on the color of the solution.

[0026]

The second light transmission window 360 is a window that transmits light from the inside of the measurement tube 310. The second light transmission window 360 is provided to the other end of the measurement tube 310. The second light transmission window 360 is, for example, a transparent material such as sapphire glass. As the second light transmission window 360, preferably selected is a material that does not dissolve easily in a solution, or a material on which the metal in the solution does not deposit easily.

[0027]

The illuminance sensor 370 detects light from the inside of the measurement tube 310 via the second light transmission window 360. The illuminance sensor 370 makes an output (for instance, voltage) according to the detected light. As the illuminance sensor 370, used is a sensor capable of detecting the wavelength of light that is absorbed by

the solution when the metal is included in the solution. The amount of light that is detected is dependent on the amount of metal in the solution. The illuminance sensor 370 is an example of the detection part.

[0028]

Here, while the first light transmission window 340 and the light source 350 were provided to one end of the measurement tube 310 and the second light transmission window 360 and the illuminance sensor 370 were provided to the other end of the measurement tube 310 in the foregoing explanation, the positions of the first light transmission window 340, the light source 350, the second light transmission window 360, and the illuminance sensor 370 are not limited thereto. The first light transmission window 340, the light source 350, the second light transmission window 360, and the illuminance sensor 370 may be disposed so that the light of the light source 350 can be detected by the illuminance sensor 370 via the solution in the measurement tube 310. For example, the first light transmission window 340 and the light source 350, and the second light transmission window 360 and the illuminance sensor 370, may be provided at opposing positions on the lateral face of the measurement tube 310.

[0029]

The control device 380 is a control means that controls the metal detector 300. The control device 380 causes light to be irradiated from the light source 350. The control device 380 acquires the detection result of light from the illuminance sensor 370. The control device 380 outputs a warning from an output means such as a display or a speaker based on the detection result of light. When the control device 380 determines that the solution contains a predetermined amount of metal or more, it outputs a warning. The control device 380 may also issue a warning to another information processing device via the communication control means. The control device 380 is an example of the control unit.

[0030]

The control device 380 can be realized by using a dedicated or general-purpose computer such as a PC (Personal Computer) or a work station (WS), or a dedicated or general-purpose computer such as an electronic device, smartphone, mobile phone, table terminal, or PDA (Personal Digital Assistant) equipped with a computer.

[0031]

Fig. 3 is a diagram showing a hardware configuration example of the information processing device. The information processing device shown in Fig. 3 has a

configuration of a general computer. The control device 380 is realized by the information processing device 90 shown in Fig. 3. The information processing device 90 of Fig. 3 includes a processor 91, a memory 92, a storage unit 93, an input unit 94, an output unit 95, and a communication control unit 96. These units are mutually connected via a bus. The memory 92 and the storage unit 93 are computer-readable recording mediums. The hardware configuration of the information processing device is not limited to the example shown in Fig. 3, and constituent elements may be suitably omitted, substituted or added.

[0032]

The information processing device 90 can realize the function that coincides with the prescribed objective by the processor 91 loading the program stored in the recording medium into the work area of the memory 92 and executing the program, and each component part being controlled through the execution of the program.

[0033]

The processor 91 is, for example, a CPU (Central Processing Unit) or a DSP (Digital Signal Processor).

[0034]

The memory 92 includes, for example, a RAM (Random Access Memory) and a ROM (Read Only Memory). The memory 92 is also referred to as a primary storage device.

[0035]

The storage unit 93 is, for example, an EPROM (Erasable Programmable ROM) or a hard disk device (HDD). Moreover, the storage unit 93 may include removable media, such as a portable recording medium. Removable media is, for example, a USB (Universal Serial Bus) memory, or a disk recording medium such as a CD (Compact Disc) or a DVD (Digital Versatile Disc). The storage unit 93 is also referred to as a secondary storage device.

[0036]

The storage unit 93 stores various programs, various data and various tables in a recording medium in a readable and writable manner. The storage unit 93 stores an operating system (OS), various programs, and various tables. The information stored in the storage unit 93 may also be stored in the memory 92. Moreover, the information stored in the memory 92 may also be stored in the storage unit 93.

[0037]

The operating system is software that mediates software and hardware, manages

memory space, manages files, and manages processes and tasks. The operating system includes a communication interface. The communication interface is a program that exchanges data with another external device connected via the communication control unit 96. The external device includes, for example, a computer, an external storage device or the like.

[0038]

The input unit 94 includes a keyboard, a pointing device, a wireless remote controller, a touch panel or the like. Moreover, the input unit 94 may also include an input device of videos and images such as a camera, and an input device of sounds such as a microphone.

[0039]

The output unit 95 includes a display device such as an LCD (Liquid Crystal Display), an EL (Electroluminescence) panel, a CRT (Cathode Ray Tube) display, or a PDP (Plasma Display Panel), and an output device such as a printer. Moreover, the output unit 95 may also include an output device of sounds such as a speaker.

[0040]

The communication control unit 96 is connected to another device, and controls the communication between the information processing device 90 and the other device. The communication control unit 96 is, for example, a LAN (Local Area Network) interface board, a wireless communication circuit for wireless communication, or a communication circuit for wired communication. The LAN interface board or the wireless communication circuit is connected to a network such as the internet.

[0041]

(Operational example)

Detection of the metal by the metal detector 300 is now explained.

[0042]

Fig. 4 is a diagram showing an example of the operational flow of the detection of the metal by the metal detector 300. Here, let it be assumed that the solution discharged from the first adsorption part 100 has been introduced into the metal detector 300.

[0043]

In S101, the control device 380 of the metal detector 300 causes light to be irradiated from the light source 350. The light source 350 irradiates light toward the measurement tube 310 based on instructions from the control device 380. Light from the light source 350 is directed toward the illuminance sensor 370. Light from the light source 350 is

absorbed by the solution in the measurement tube 310. More light from the light source 350 is absorbed as the amount of metal contained in the solution in the measurement tube 310 is greater.

[0044]

In S102, the control device 380 causes the illuminance sensor 370 to detect light. The illuminance sensor 370 makes an output based on the amount of light that was detected. The illuminance sensor 370 outputs, for example, a voltage based on the amount of light that was detected. The control device 380 acquires the output of the illuminance sensor 370. The amount of light detected by the illuminance sensor 370 will be less as the amount of metal contained in the solution in the measurement tube 310 is greater.

[0045]

In S103, the control device 380 determines whether the amount (concentration) of metal contained in the solution in the measurement tube 310 is equal to or greater than a predetermined value. The control device 380 measures in advance the relationship of the concentration of the metal contained in the solution in the measurement tube 310 and the output of the illuminance sensor 370. The control device 380 determines that the concentration of metal in the measurement tube 310 is equal to or greater than a predetermined value when the output of the illuminance sensor 370 indicates that the concentration of metal in the measurement tube 310 is equal to or greater than a predetermined value. The control device 380 determines that the concentration of metal in the measurement tube 310 is less than a predetermined value when the concentration of metal in the measurement tube 310 is less than a predetermined value. When the control device 380 determines that the concentration of metal in the measurement tube 310 is equal to or greater than a predetermined value (S103; YES), the processing proceeds to S104. When the control device 380 determines that the concentration of metal in the measurement tube 310 is less than a predetermined value (S103; NO), the processing returns to S102.

[0046]

In S104, the control device 380 outputs a warning with an output means such as a display or a speaker indicating that the metal in a concentration that is equal to or greater than a predetermined value. For example, the control device 380 indicates a message to the effect of "The concentration of metal in the solution is now equal to or greater than a predetermined value" on a display. Moreover, for example, the control

device 380 outputs a message to the effect of “The concentration of metal in the solution is now equal to or greater than a predetermined value” or a warning sound from a speaker. The warning is issued to the administrator of the metal recovery system 10. The administrator that received the warning will recognize that the adsorbent of the first adsorption part 100 has reached its absorption limit, and replace the adsorbent of the first adsorption part 100. The control device 380 may also issue a warning to another information processing device owned by the administrator of the metal recovery system 10 via the communication control means. The processing thereafter returns to S102.

[0047]

The metal detector 300 can instantaneously detect that the concentration of metal contained in the solution is now equal to or greater than a predetermined value by constantly detecting light and detecting the concentration of metal contained in the solution.

[0048]

(Relationship of solution, irradiation and detected color)

The absorbed color will differ depending on the metal remaining in the solution. Thus, proper detection is difficult unless the metal remaining in the solution is irradiated with suitable light. The complementary color of the liquid color of the solution under white light is the absorbed color. Thus, the color of light of the light source 350 is decided depending on the liquid color of the solution under white light. The color of light of the light source 350 is preferably the complementary color of the liquid color of the solution under white light.

[0049]

When the solution is a palladium catalyst solution, the liquid color under white light is a brown color (orange color). The complementary color of a brown color (orange color) is a green-blue color or a blue-green color (blue color). Thus, with a palladium catalyst solution, it is preferable to use light including a green-blue color or a blue-green color as the light source 350. The main components of a palladium catalyst solution are tetraammine palladium and diammine dinitrito palladium.

[0050]

When the solution is a palladium tin catalyst solution, the liquid color under white light is a black-brown color. The complementary color of a black-brown color is a green-blue color. Thus, with a palladium tin catalyst solution, it is preferable to use light

including a green-blue color as the light source 350. The main components of the palladium tin catalyst solution are palladium nano particles.

[0051]

When the solution is a solution containing dichlorodiammine palladium for use in palladium plating, the liquid color under white light is a yellow color or an orange color. The complementary color of a yellow color or an orange color is a blue color or a blue-green color. Thus, with a solution containing dichlorodiammine palladium, it is preferable to use light including a blue color or a blue-green color as the light source 350.

[0052]

When the solution is a solution containing a gold sodium sulfite solution for use in non-cyanide gold plating, the liquid color under white light is a light yellow color. The complementary color of a light yellow color is a blue color. Thus, with a solution containing a gold sodium sulfite solution, it is preferable to use light including a blue color as the light source 350.

[0053]

When the solution is a solution containing dinitrodiammine platinum for use in platinum plating, the liquid color under white light is a light yellow color. The complementary color of a light yellow color is a blue color. Thus, with a solution containing dinitrodiammine platinum, it is preferable to use light including a blue color as the light source 350.

[0054]

When the solution is a solution containing dirhodium trisulphate for use in rhodium plating, the liquid color under white light is an orange color or a red color. The complementary color of an orange color or a red color is a green-blue color or a blue-green color. Thus, with a solution containing dinitrodiammine platinum, it is preferable to use light including a green-blue color or a blue-green color as the light source 350.

[0055]

<Example 1>

Fig. 5 is a diagram showing an example of the relationship (1) between the output of the illuminance sensor and the metal concentration of the solution. Here, a palladium catalyst solution was used as the solution, the irradiation and detection of light were performed by the metal detector 300, and the relationship between the metal concentration (palladium concentration) of the palladium catalyst solution and the

output voltage of the illuminance sensor 370 was checked. The main components of the palladium catalyst solution are tetraammine palladium and diammine dinitrito palladium. Here, a blue color LED (wavelength of 460 nm) was used as the light source 350. The measurement tube 310 was irradiated with light from the light source 350, and light was detected with the illuminance sensor 370. The light detected with the illuminance sensor 370 is the light irradiated from the light source 350. Because the liquid color of the palladium catalyst solution under white light is a brown color, a blue color corresponds to the complementary color. The metal concentration of the palladium catalyst solution (palladium concentration of the solution) has been measured in advance. The illuminance sensor 370 used here outputs a lower voltage as the amount of light that is detected is greater.

[0056]

As shown in Fig. 5, it can be understood that the output voltage of the illuminance sensor 370 becomes higher as the palladium concentration (Pd concentration) of the solution is higher. In other words, it can be understood that the amount of light is decreasing (light is being absorbed) as the palladium concentration is higher. Thus, for example, when the palladium concentration of 1 mg/L is used as the warning threshold, the control device 380 can output the warning when the output voltage of the illuminance sensor 370 becomes 0.20 V or higher. The concentration of the warning threshold is not limited to the foregoing example, and may be arbitrarily set.

[0057]

<Example 2>

Fig. 6 is a diagram showing an example of the relationship (2) between the output of the illuminance sensor and the metal concentration of the solution. Here, a palladium catalyst solution was used as the solution, the irradiation and detection of light were performed by the metal detector 300, and the relationship between the metal concentration (palladium concentration) of the palladium catalyst solution and the output voltage of the illuminance sensor 370 was checked. The main components of the palladium catalyst solution are tetraammine palladium and diammine dinitrito palladium. Here, an orange LED (wavelength of 600 nm) was used as the light source 350. The measurement tube 310 was irradiated with light from the light source 350, and light was detected with the illuminance sensor 370. The light detected with the illuminance sensor 370 is the light irradiated from the light source 350. Because the liquid color of the palladium catalyst solution under white light is a brown color, an

orange color does not correspond to the complementary color. The metal concentration of the palladium catalyst solution (palladium concentration of the solution) has been measured in advance. The illuminance sensor 370 used here outputs a lower voltage as the amount of light that is detected is greater.

[0058]

As shown in Fig. 6, it can be understood that there is no change to the output voltage of the illuminance sensor 370 even when there is a change to the palladium concentration (Pd concentration) of the solution. In other words, it can be understood that there is no change to the amount of light even when there is a change to the palladium concentration. Thus, it can be understood that it would be unfit to use a color other than the complementary color of the liquid color of the solution as the light source 350.

[0059]

(Operation and Effect of Embodiments)

The metal recovery system 10 of this embodiment adsorbs the metal contained in the solution with the adsorbent of the first adsorption part 100. The metal recovery system 10 uses the metal detector 300 to detect the concentration of the metal remaining in the solution ejected from the first adsorption part 100, and issues a warning when the detected concentration is equal to or greater than a predetermined value. The metal detector 300 constantly detects light with the illuminance sensor 370. The administrator of the metal recovery system 10 can replace the adsorbent of the first adsorption part 100 based on the warning. As a result of constantly detecting the metal concentration with the metal detector 300, it is possible to quickly replace the adsorbent when there is any leakage of the metal from the first adsorption part 100.

[0060]

The metal detector 300 detects the metal concentration of the solution by irradiating the solution ejected from the first adsorption part 100 with light from the light source 350 including the complementary color of the liquid color of the solution, and using the illuminance sensor 370 to detect the amount of light that was absorbed. The metal detector 300 can comprehend the metal concentration of the solution by using light, without having to extract the solution and measuring the metal concentration.

[0061]

The embodiments described above are worked by being combined to the extent possible.

[Description of Reference Numerals]

[0062]

10: metal recovery system
100: first adsorption part
200: second adsorption part
300: metal detector
310: measurement tube
320: inlet tube
330: outlet tube
340: first light transmission window
350: light source
360: second light transmission window
370: illuminance sensor
380: control device
410: first pipe
420: second pipe
430: third pipe
440: fourth pipe
90: information processing device
91: processor
92: memory
93: storage unit
94: input unit
95: output unit
96: communication control unit

[CLAIMS]

[Claim 1]

A metal recovery system for recovering a metal contained in a solution, including:
a first adsorption part that adsorbs the metal contained in the solution,
a metal detector that detects the metal remaining in the solution ejected from the first adsorption part, and
a second adsorption part that adsorbs the metal contained in the solution ejected from the metal detector,
wherein the metal detector comprises:
a cylindrical tube through which flows the solution containing the metal ejected from the first adsorption part;
a light source that irradiates inside of the tube with light of a complementary color of a liquid color of the solution containing the metal under white light;
a detection part that detects light from inside the tube; and
a control unit that acquires a detection result from the detection part,
wherein the control unit determines whether a metal concentration of the metal contained in the solution is equal to or greater than a predetermined value based on the detection result.

[Claim 2]

The metal recovery system according to claim 1,
wherein the solution containing the metal is a solution containing tetraammine palladium, and diammine dinitrito palladium, and
the complementary color is a blue color.

[Claim 3]

The metal recovery system according to claim 1 or claim 2,
wherein the tube is linear,
the light source is provided to one end of the tube, and
the detection part is provided to another end of the tube.