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(54) METHOD AND APPARATUS FOR PROVIDING STABLE VOLTAGE TO ANALYTICAL SYSTEM

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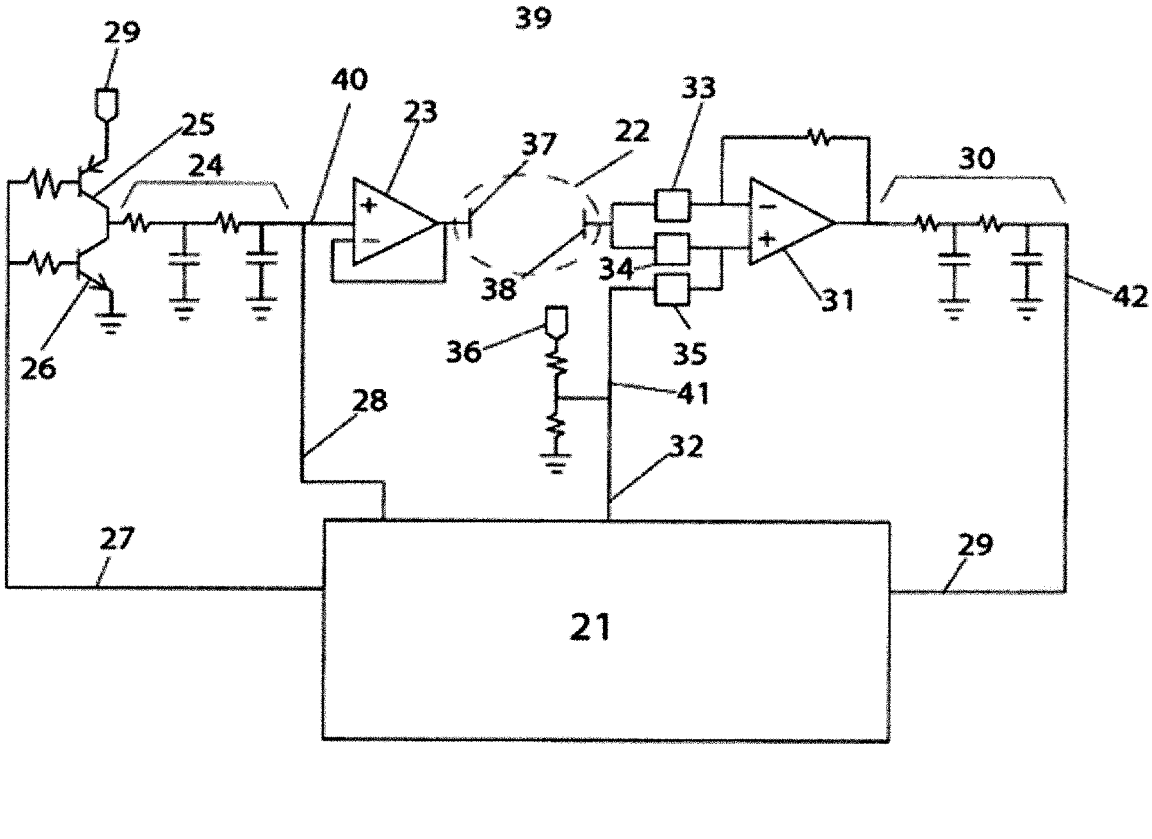
(57) **ABSTRACT**

Abstract of the Disclosure

An electrochemical cell has two terminals. One of the terminals is connected to a pulse-width-modulated (PWM) power supply and to a voltmeter. The other terminal is connected to circuitry capable of switching between amperometric and potentiometric measurement modes. A sequence of successive approximations permits selection of a PWM duty cycle giving rise to a desired voltage at the terminal connected with the power supply. In this way a stable excitation voltage is supplied to the cell even in the face of supply voltage instability or drift or instability in electronics coupled with the cell.



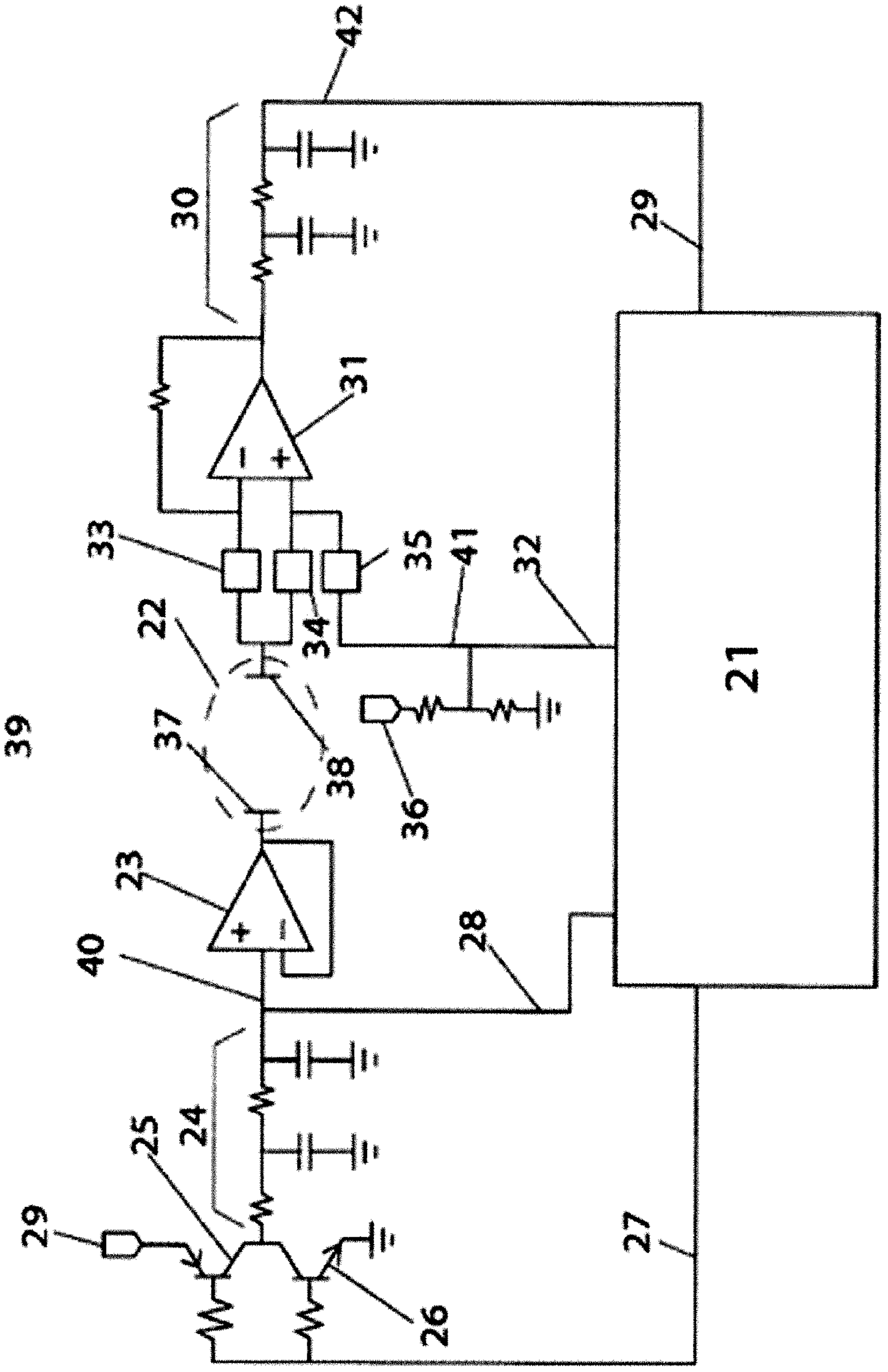


Fig. 1

METHOD AND APPARATUS FOR PROVIDING STABLE VOLTAGE TO ANALYTICAL SYSTEM

Detailed Description of the Invention

Background

[0001] It is not easy to make repeatable and accurate measurements in analytical systems such as consumer devices using an electrochemical cell. Many constraints contribute to the difficulty of this task. The consumer device must be light in weight, small and reliable. The price cannot be too high. The device may be running on a new battery or an old one, and the user cannot be relied upon to perform manual calibration steps. The repeatability and accuracy of the measurements must be preserved even in the face of temperature changes and user decisions such as whether or not to use a display backlight.

Summary of the invention

[0002] An electrochemical cell has two terminals. One of the terminals is connected to a pulse-width-modulated (PWM) power supply and to a voltmeter. The other terminal is connected to circuitry capable of switching between amperometric and potentiometric measurement modes. A sequence of successive approximations permits selection of a PWM duty cycle giving rise to a desired voltage at the terminal connected with the power supply. In this way a stable excitation voltage is supplied to the cell even in the face of supply voltage instability or drift or instability in electronics coupled with the cell.

Description of the drawing

[0003] **Fig. 1** shows an exemplary circuit according to the invention.

Detailed description

[0004] **Fig. 1** shows an analytical system 39 with an electrochemical cell 22. The analysis is performed under the control of a microcontroller 21. The microcontroller 21 has a pulse-width-modulated output 27 as well as analog inputs 28, 32 and 29. The analog inputs 28, 32, 29 are (in an exemplary embodiment) connected by means of a multiplexer internal to the microcontroller 21 to an analog-to-digital converter also internal to the multiplexer 21. PWM signal 27 controls transistors 25, 26 which, through filter 24, develop a voltage at point 40 (called V2). This voltage passes through buffer 23 to electrode 37 which, in an exemplary embodiment, is a working electrode. The voltage V2 can be measured by the microcontroller via line 28.

[0005] The other electrode 38 of the cell 22 is connected by switches 33, 34, 35 to a reference voltage VREF at point 41 and to an operational amplifier 31. The voltage at point 41 can be measured by the microcontroller via line 32.

[0006] Depending on the positions of switches 33, 34, 35, the amplifier 31 is able to serve as a voltmeter or an ammeter. When it serves as an ammeter it is measuring the current through electrode 38 and thus through the reaction cell 22, and it gives rise to a voltage at point 42 that is indicative of the current. When it serves as a voltmeter it is measuring the voltage at electrode 38, and this gives rise to a voltage at point 42 that is indicative of the voltage. In either case, the microcontroller 21 is able, via line 29, to measure the voltage at point 42. Low-pass filter 30 is provided.

[0007] As a first step, the microcontroller 21 measures the voltage at the counter electrode 38. This measurement is relative to the working electrode 37, meaning that the microcontroller 21 will need to measure the voltages on lines 28 and 29 nearly contemporaneously.

[0008] It will be appreciated that both of the operational amplifiers 23, 31 are on the same chip. Thus to a first approximation the offsets and temperature drifts for the two op amps are likely to be about the same.

[0009] Next the microcontroller 21 guesses at a PWM duty cycle that may give rise to a desired voltage at the working electrode 37. The duty cycle is applied and time is allowed to pass so that the PWM filtered voltage is stable.

[0010] Next the microcontroller 21 measures the voltage at 40 again, and in a recursive way the PWM duty cycle is adjusted to come closer to the desired voltage at 40.

[0011] This cycle may be repeated several times.

[0012] In the case where the apparatus is being used to analyze a bodily fluid or other analyte, this sequence takes place:

[0013] Before the analyte has been introduced into the cell, V2 (the voltage at 40) is calibrated. The voltage V1 (the voltage at 41) is monitored.

[0014] Next the analyte is introduced into the cell 22. The microcontroller 21 performs the calibration again. It monitors V2. It monitors V1. The microcontroller 21 measures the output of the second op amp 31. In this way analytical measurements are carried out with respect to the analyte in the cell 22.

[0015] This approach uses inexpensive components and thus helps to minimize cost.

[0016] Those skilled in the art will have no difficulty devising myriad obvious improvements and variations upon the embodiments of the invention without departing from the invention, all of which are intended to be encompassed by the claims which follow.

What is Claimed is:

1. A method for use with a digitally controlled power supply, a reaction cell having first and second electrodes, the power supply coupled with the first electrode, a first signal line coupling the first electrode with a first analog-to-digital convertor, and a voltage sensor coupled with the second electrode, the voltage sensor having a second signal line coupled with a second analog-to-digital convertor, the method comprising the step which follow in the order given: measuring a potential at the second electrode by means of the second signal line; making a first approximation to a digital control signal for the power supply; measuring a potential at the first electrode by means of the first signal line; making a second approximation to the digital control signal for the power supply; measuring a potential at the first electrode by means of the first signal line; making a third approximation to the digital control signal for the power supply; measuring a potential at the second electrode by means of the second supply line.

2. The method of claim 1 wherein the power supply is a pulse-width-modulated power supply and the steps of making approximations to digital control signals each comprises making an approximation to a duty cycle for pulse-width-modulating the control signal.

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