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ANALYSIS OF TOXIC GAS MONITORING SYSTEMS

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ABSTRACT

This paper describes a general design procedure for the implementation of a gas monitoring system which uses an optical sensor as the measuring transducer. The drawbacks of such systems and possible solutions are primarily discussed.

INTRODUCTION

A simple gas concentration level detector can be constructed by using one of several commercially available paper tape cassettes. Such tapes are chemically treated, and will respond by changes in surface color (referred to as stain levels) when a short section is exposed to a particular gas. Stain levels are a function of present gas concentration, and will be different for the application in use. Thus by a selection of an appropriate tape cassette, one can monitor a variety of gases.

THE TRANSDUCER

Stain levels are detected by an opto-electric circuit consisting of a light source and a sensitive photocell. The photocell is mounted in such a way as to view any light reflected by the effected paper tape surface as shown in Figures 1A and 1B. The sampled gas is delivered by a low compression diaphragm pump, via a simple nozzle aimed directly at the tape surface.

TAPE TRANSPORT AND RELATED CONTROLS

Tape stain levels are irreversable, therefore a motorized transport system must be devised to continuously or sequentially advance unexposed tape sections in front of the transducer. Such transport can be implemented by using a DC, or stepping motor turning a capstan drive, along with a rubber pinch roller, to provide enough friction for smooth tape advancement, as shown in Figure 2.

Although a continuous tape transport can be successfully used, it is not advised, since it will result in unnecessary tape usage and reduce monitoring system cost efficiency, due to frequently needed tape cassette changes.

On the other hand, a sequential transport will increase efficiency but will require added control circuitry, since it must advance the tape by one or two inch increments and then stop. Another added benefit results from the fact that a gas sampling can be manually, or interval timed initiated, as the need arises. All system controls can be provided by a dedicated discrete logic or a software controlled microprocessor circuit. The latter will be of primary interest since it will offer greater user flexibility.

DESCRIPTION

Because of inherent variations in paper tape pigment distribution, one finds that the transducer will provide a tape position voltage variant output, even though sampled gas is not present. Such tape background noise will add to, or subtract from a pre-established zero concentration level reference voltage, resulting in a signal output error.

THE CIRCUIT

To obtain full usable resolution and range provided by paper tape, an amplifier with a minimum pre-determined gain must be interfaced to the transducer output. As a result, any tape background noise is also amplified, which will in turn degrade monitoring system accuracy. Such error can be corrected by using a sample and hold circuit shown in Figure 3. This configuration will allow any positive or negative error voltage cancellation from the actual output signal. It is important to note that the sample and hold droop rate will be amplified if the output signal of the sample and hold circuit drives any amplifier.

Results well within the tape accuracy can be obtained by the selection of a sample and hold circuit with a droop rate of 1 to 2 mV per minute. Such a circuit can be constructed by using a high grade FET Op-Amp and holding capacitor.

With such a restriction, the paper tape should be advanced within a one minute interval for each monitoring cycle.

The corrected signal can in turn be used to drive a meter movement calibrated in parts per million, thus depicting gas concentration levels.

AN ALTERNATIVE

A more sophisticated error cancelling and control circuitry can be implemented by using a dedicated microprocessor sub-system in conjunction with an analog to digital converter. In this configuration and A/D can present a binary equivalent error voltage of the unexposed paper tape to the microprocessor, where under software supervision it can be subtracted from or added to the uncorrected output signal, which is also in a binary form. As an added advantage, the microprocessor can also be used to perform system house-keeping functions as: tape incrementing, activation of delivery pump, and updating controls for a digital display, as shown in Figure 4. A comparison look-up table correlating corrected binary outputs versus pre-established gas concentration levels can now reside in the microprocessor sub-system ROM. When under software control, it can be matched and interpreted as the actual gas concentration level, which can be presented by a digital display in parts per million.

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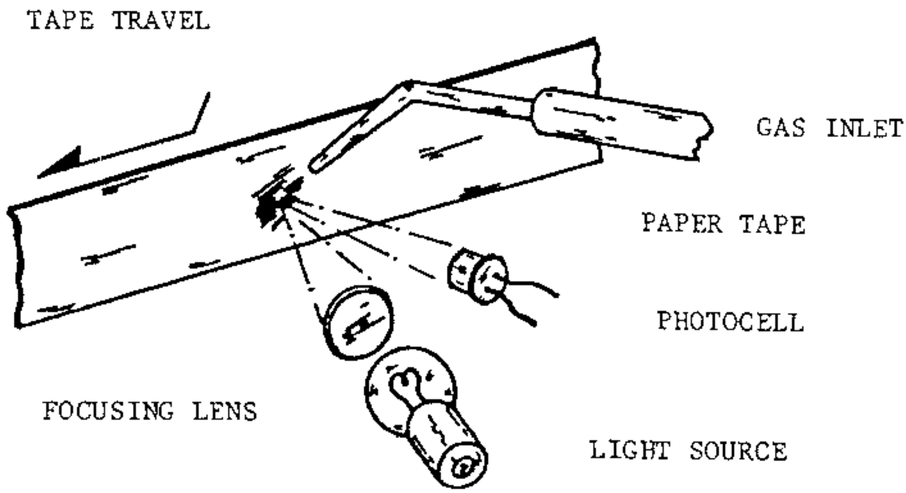

FIG. 1A TRANSDUCER PICTORIAL

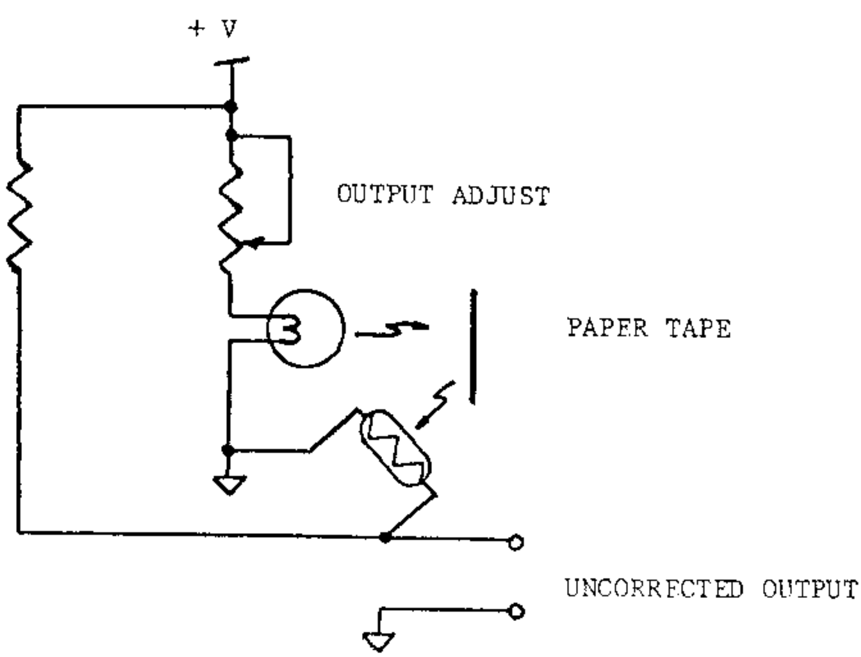

FIG. 1B TRANSDUCER SCHEMATIC

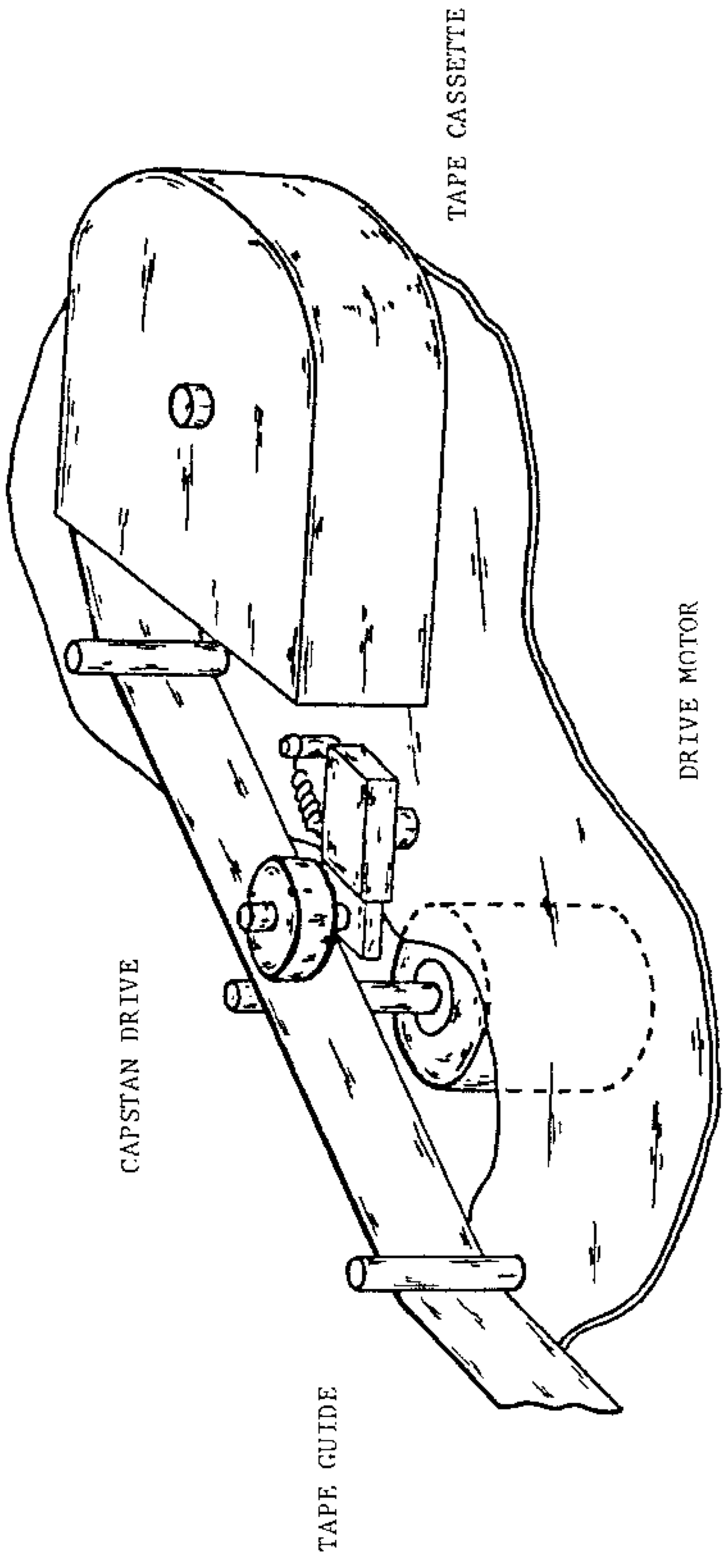

FIG. 2 TRANSPORT SYSTEM

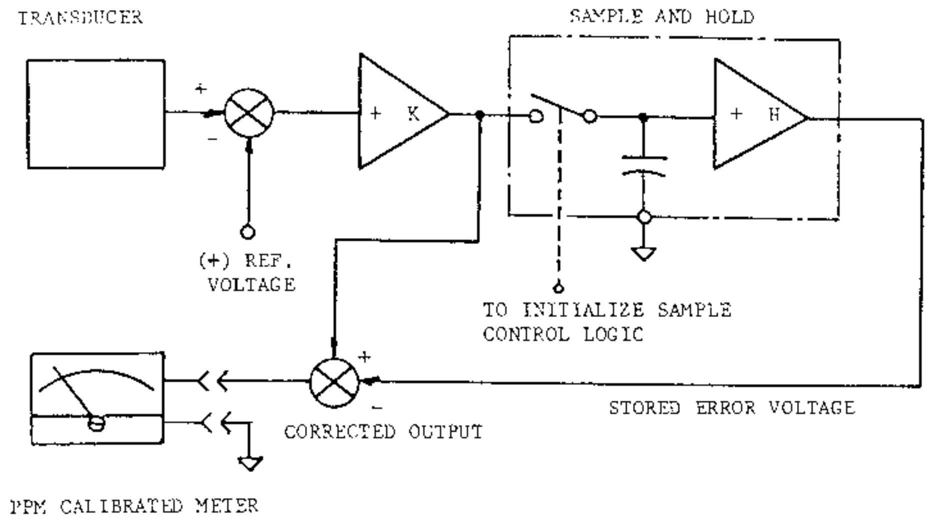

FIG. 3 ANALOG CORRECTION CIRCUIT

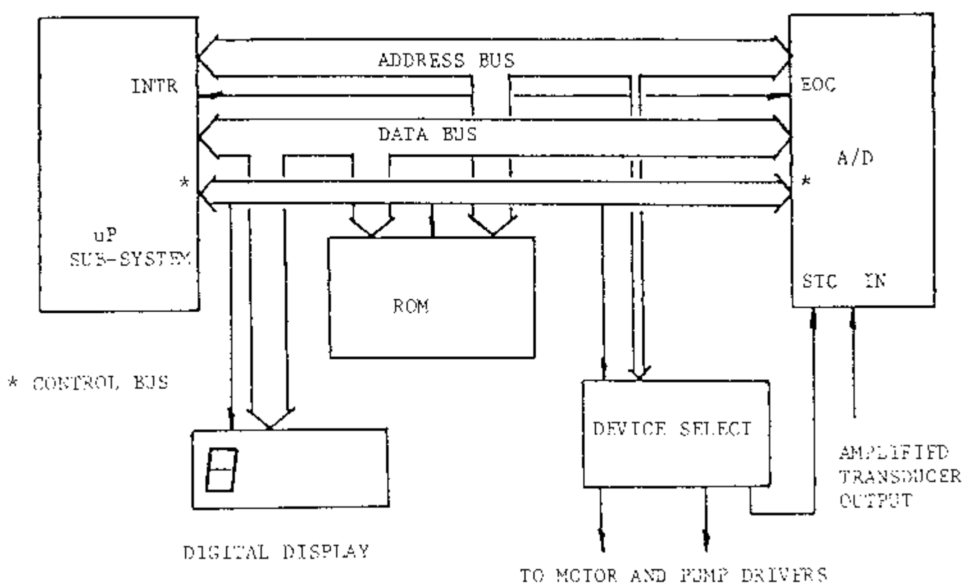

FIG. 4 uP SUB-SYSTEM DIAGRAM