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MASTER

ACOUSTIC EMISSION INTRUSION DETECTOR

D. W. Carver

April 1978

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OAK RIDGE, TENNESSEE

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ACOUSTIC EMISSION INTRUSION DETECTOR

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Prepared for the Department of Energy
Under US Government Contract W-7405-eng-26

ABSTRACT

In order to improve the security of handling special nuclear materials at the Oak Ridge Y-12 Plant, a sensitive acoustic emission detector has been developed that will detect forcible entry through block or tile walls, concrete floors, or concrete/steel vault walls. A small, low-powered processor was designed to convert the output from a sensitive, crystal-type acoustic transducer to an alarm relay signal for use with a supervised alarm loop. The unit may be used to detect forcible entry through concrete, steel, block, tile, and/or glass.

CONTENTS

SUMMARY

As part of the Safeguards program at the Y-12 Plant, a sensitive acoustic emission device has been developed that will detect forcible entry through block or tile walls, concrete floors, or concrete/steel vault walls. A small, low-powered processor was designed to convert the transducer output to an alarm relay signal for use with a supervised alarm loop. The unit may be used to detect forcible entry through walls, ceilings, or floors of many different types of construction.

INTRODUCTION

In response to an increased effort to improve the security of handling special nuclear materials at the Oak Ridge Y-12 Plant,[a] a number of intrusion alarm systems were evaluated and installed. However, a sensitive alarm with a negligible nuisance alarm rate usable on many different types of walls, floors, and ceilings was not commercially available. To fill this need, a sensitive acoustic emission detector was designed. The nuisance alarm rate of the detector has been extremely low during approximately nine months of use. Power requirements for the processor were minimized through the use of complementary metal oxide semiconductor (CMOS) amplifiers and integrated circuits. The standby (no alarm) current required is less than 200 microamperes at 9.6 volts. The unit can operate from a small trickle-charged nickel/cadmium battery for days or weeks without primary power.

(a) Operated by the Union Carbide Corporation's Nuclear Division for the Department of Energy.

ACOUSTIC EMISSION DETECTOR

CIRCUIT DESCRIPTION

The acoustic emission transducers which are used for the detector are sensitive, crystal-type transducers that are attached to a smooth surface on the interior walls of the room or vault being monitored. A typical signal output from the transducer, due to a hammer-type blow on concrete or tile walls, is a damped sinusoid of approximately 5 milliseconds duration at a frequency of 1100 to 1300 Hz. The initial amplitude of the signal varies with the type of construction and distance from the disturbance to the detector, but it is typically 5 to 10 millivolts. When the transducer is attached to the steel in a reinforced wall, the output signal due to a hammer blow or metal saw stroke is a similar output of approximately 15 milliseconds duration at about 3500 Hz. Typical outputs from the transducer for a disturbance in concrete or concrete/steel walls are illustrated in Figures 1 and 2.

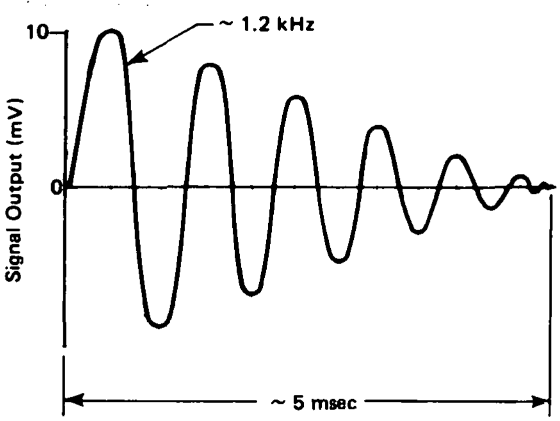

Figure 1. TYPICAL SIGNAL OUTPUT FOR A HAMMER BLOW ON VAULT CONCRETE.

A small, low-powered processor was designed to convert the transducer output to an alarm relay signal for use in conjunction with a supervised alarm loop. The processor, which is constructed on a single printed circuit board approximately 3 inches by 5 inches (Figure 3), consists of a 40-decibel maximum preamplifier stage with a field-effect transistor input followed by an adjustable (switch-selected) second amplifier stage of 20 decibel, maximum, for overall gain selection. In addition, the second amplifier rectifies the amplified transducer signal before routing the signal to the digital portion of the circuit. The low-frequency cutoff is fixed at about 800 Hz. The amplifier is followed by a Schmitt trigger and timing circuit which rejects

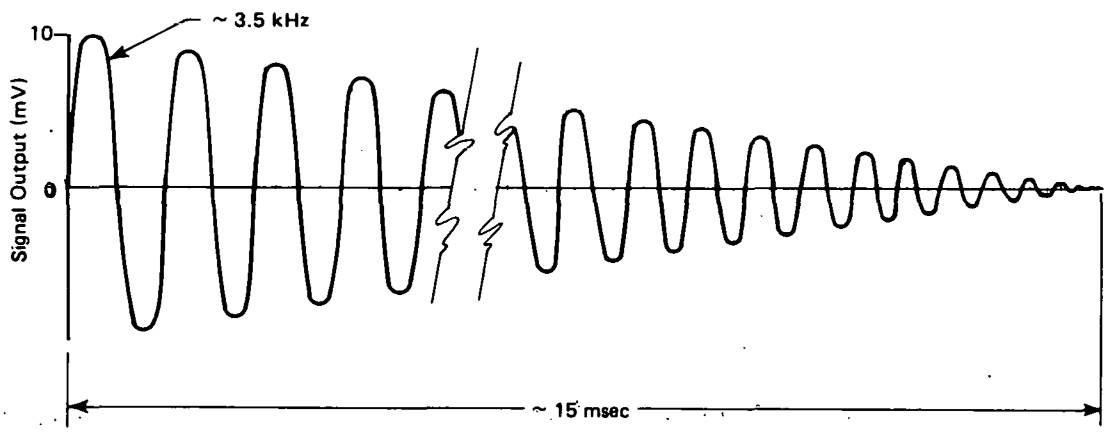

Figure 2. TYPICAL OUTPUT FOR A HAMMER BLOW OR METAL SAW STROKE ON VAULT STEEL.

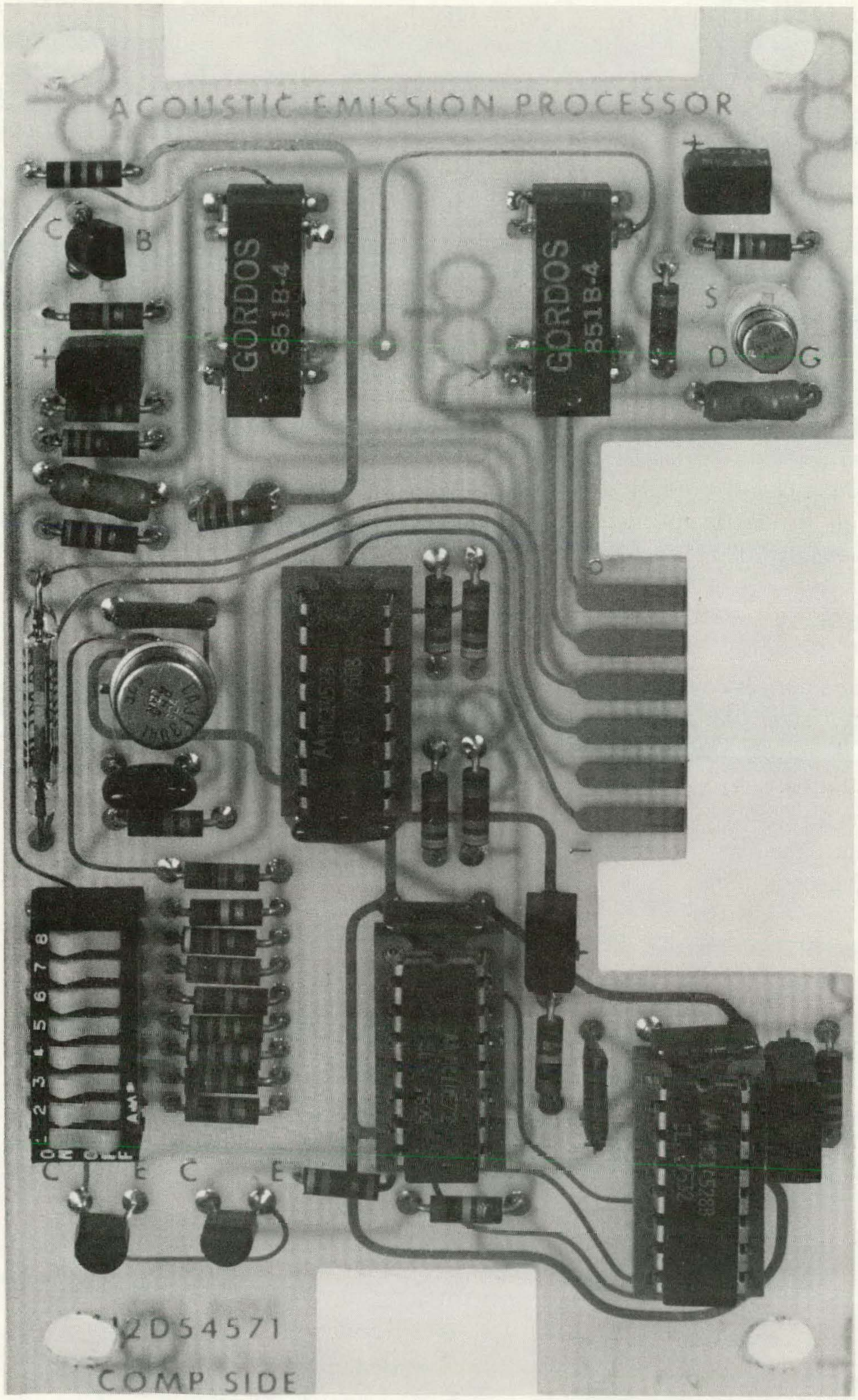

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Figure 3. PROCESSOR PRINTED CIRCUIT BOARD.

low-frequency periodic signals. When the disturbance detected by the transducer is determined to have sufficient amplitude and proper frequency, the signal is routed to pulse-shaping circuitry, followed by a relay driver. Miniature reed relays with isolated contacts are provided for the supervised alarm loop and a recorder, if needed. A block diagram of the circuit is given in Figure 4.

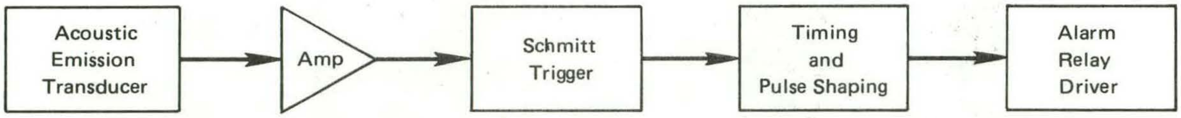

Figure 4. PROCESSOR CIRCUIT.

An audible signal is generated when an alarm condition is detected. The audible alert is provided primarily for sensitivity setup of the processor. The entire unit is housed in a 2 by 3 by 6-inch box (Figure 5) which includes a tamper switch, recorder output connector, and a conduit fitting for the alarm and tamper-loop wiring. The standby current (no alarm) is approximately 200 microamperes at 9.6 volts.

RESULTS

The detector has performed well on concrete, steel, block, tile, and glass. Table 1 gives the minimum impact momentum for an alarm to occur, using the least sensitive of eight gain settings for the unit. There were no known nuisance alarms, over a six-month period, from an installation consisting of eight detectors. More recently, an installation of two detectors has produced no nuisance alarms for a period of three weeks.

Table 1

MINIMUM IMPACT MOMENTUM FOR ALARM

Wall/Vault Construction	Momentum (kg · m/sec)	Distance to Detector (m)
Tile Block	0.3	4.0
Concrete Block	2.6	4.0
Steel-Reinforced Concrete	5.3	4.0

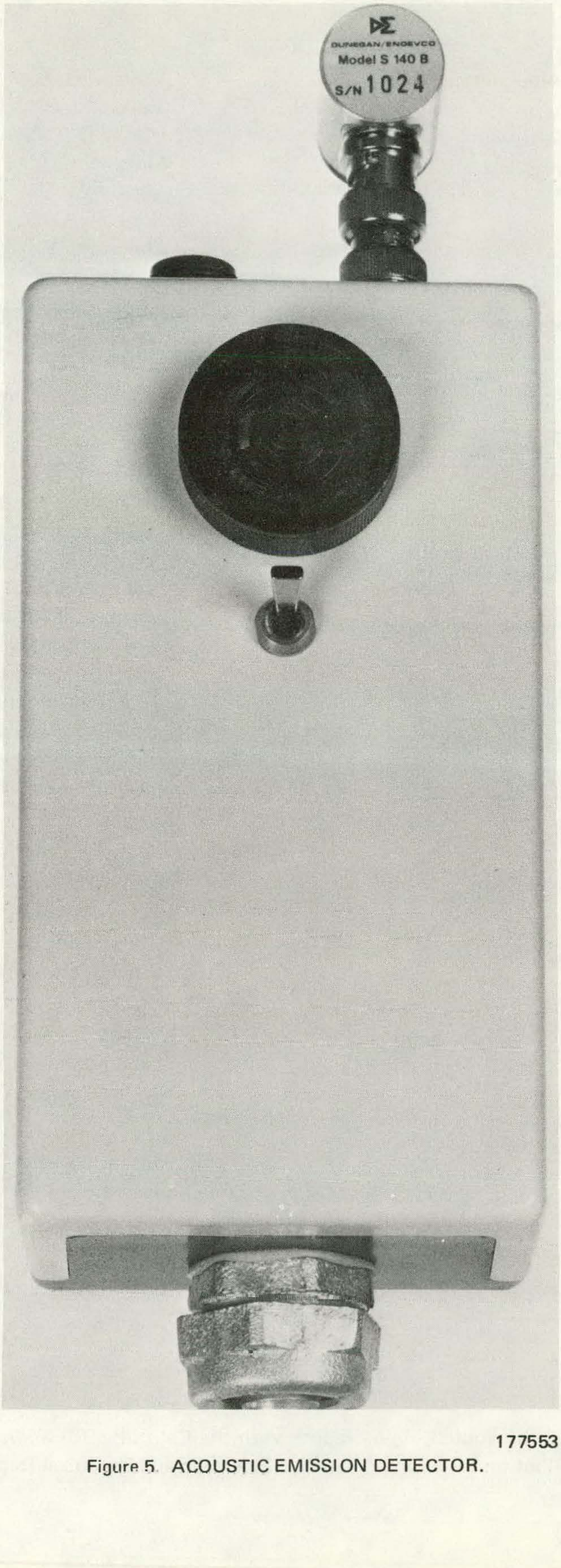

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Figure 5. ACOUSTIC EMISSION DETECTOR.

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