AECL-5385

ATOMIC ENERGY OF CANADA LIMITED

L'ÉNERGIE ATOMIQUE DU CANADA LIMITÉE

GAMMA SCANNING OF LARGE SIEVE TRAY TOWERS

by

D.D. McCAW, V.G. HULBERT and A.E. SMITH

Colloquium paper B/03 presented at NUCLEX 75, International Nuclear Industries Fair and Technical Meeetings, 7-11 October 1975, Basel, Switzerland.

Chalk River Nuclear Laboratories
Chalk River, Ontario

January 1976

GAMMA SCANNING OF LARGE SIEVE TRAY TOWERS*

by

D.D. McCaw, V.G. Hulbert and A.E. Smith

Chalk River Nuclear Laboratories
Chalk River, Ontario
January 1976

*Colloquium paper B/03 presented at NUCLEX 75, International Nuclear Industries Fair and Technical Meetings, 7-11 October 1975, Basel, Switzerland.

Reprinted by Atomic Energy of Canada Limited with permission of the organizers.

AECL-5385

GAMMA SCANNING OF LARGE SIEVE TRAY TOWERS

by

D.D. McCaw, V.G. Hulbert and A.E. Smith

Atomic Energy of Canada Limited

SUMMARY

A special instrument based on the use of gamma rays, has been developed, which assists in the evaluation of the effects of changes in controlled variables on sieve tray performance. Internal structural damage, and local tray flooding are readily detectable from outside the vessel.

The instrument is described, and examples of its use are given.

ZUSAMMENFASSUNG

Ein auf der Verwendung von Gammastrahlen basierendes Spezialinstrument ist entwickelt worden, mit dem sich feststellen läßt, welche Auswirkungen eine Änderung gewisser vorbestimmter Betriebsbedingungen auf die Leistung von Siebplattenkolonnen hat. Mit dem Instrument können in der Kolonne auftretende Schäden und eine etwaige Überbelastung der Siebplatten leicht von außen beobachtet werden.

Das Instrument selbst und einige Anwendungsbeispiele werden beschrieben.

RÉSUMÉ

Un instrument spécial employant des rayons gamma a été développé pour contribuer à l'évaluation de l'effet du changement des variables contrôlées, sur la performance des plateaux perforés. Placé à l'extérieur d'une enceinte, cet instrument permet de détecter facilement les dommages structurels et les inondations locales des plateaux qui surviennent à l'intérieur de l'enceinte.

On trouvera dans le présent rapport une description de l'instrument et des exemples d'utilisation.

Chalk River Nuclear Laboratories
Chalk River, Ontario
January 1976

AECL-5385

Colloquium paper B/03 presented at NUCLEX 75, International Nuclear Industries Fair and Technical Meetings, 7-11 October 1975, Basel, Switzerland.

Reprinted by Atomic Energy of Canada Limited with permission of the organizers.

INTRODUCTION

The need to know more about liquid levels and foam heights on the trays of our Heavy Water Plant Towers led to the development of a special instrument based on the use of Gamma rays. In addition to its primary function, the device has proven useful for detecting hole plugging in sieve trays, and internal structural damage. A simplified diagram of The Gamma Scanner arrangement is shown in Figure 1.

The Towers are 85 metres high and 8.5 metres in diameter, with 8.9 cm thick walls. A beam of high energy radiation, from a ^{60}Co source, is passed through the vessel and is detected with a NaI crystal and photomultiplier. The amplified signal is fed to a single channel analyser, windowed on the ^{60}Co energy peaks. The output of the analyser, which is displayed on a counter and on a strip chart recorder, is a function of the distance between the source and the detector, and of the density of the intervening material. Since the beam path length and vessel wall thickness are constant, the output of the instrument is an analog of the density of the material inside the vessel. Now, if the source and detector are moved synchronously, up or down the Tower, the instrument traces out a density profile which can be interpreted in terms of tray hardware, liquid levels, and froth heights. The change in liquid and froth levels provides a sensitive indicator of the effects of controlled variables on Tower operation.

Two small elevators, located on opposite sides of the Tower, raise or lower the source and detector. The common control unit permits selection of scanning rate and direction, and has provision for setting upper and lower limits on elevator travel. A digital indicator displays the elevation in decimetres.

DESCRIPTION OF EQUIPMENT

The ^{60}Co source is mounted in a hemispherical block of depleted Uranium, see Fig. 2. A conical aperture in the shielding permits a beam of gamma radiation to be directed through the Tower towards the detector. Radiation fields in all other directions are low (about 150 mr/h at 1 metre). The source and its holder are mounted in a carrier assembly, which is designed to fit inside a storage/shipping flask, when not in use (Fig. 3). The source carrier is attached to a guided elevator carriage during a Tower scan (Fig. 4).

The detector assembly consists of a lead collimator, a thallium activated NaI crystal, with photomultiplier tube and pre-amplifier, all mounted in a guided elevator carriage (Fig. 5). The collimator is used to reduce the incidence of secondary rays scattered from the Tower structure, which appear as background noise in the detection circuits.

Power and signal cables attached to the detector and carried by its elevator carriage, lead back to an electronics cabinet (Fig. 6), which houses a high voltage supply, signal amplifier, peak stabilizer and single channel analyser. The latter, which is windowed on the ^{60}Co energy peaks, drives digital and analog count rate meters, a strip chart recorder, and a printer.

Primary gamma rays from the ^{60}Co source are attenuated severely by distance and absorption. About 200 counts per second are detected by the scintillator, when scanning a "dry" Tower. The bottom end of the scale is determined by the ambient background radiation. Since counting statistics are improved by longer counting time, Tower scans are done very slowly, at 5 to 15 cm/min. In general, the slower the scanning rate, the greater the resolution.

The elevators, carrying the source and detector, are driven by stepping motors, synchronized by a common position controller (Fig. 7) which was designed with special features for this application. The position controller permits selection of the speed, direction, and limits of elevator travel, by means of switches located on the front panel. The elevation is indicated in decimetres, and position feed-back from each elevator drive is monitored by a comparator circuit, to ensure that source and detector positions are synchronized. Provision of a manual mode of operation permits the elevators to be moved independently for initial alignment and calibration. All of the electrical and electronic equipment, except the position controller, are commercially available. The mechanical drive and cable drum assemblies (Fig. 8) were specially designed to suit. A block diagram of the portable gamma scanner is shown in Figure 9.

APPLICATION

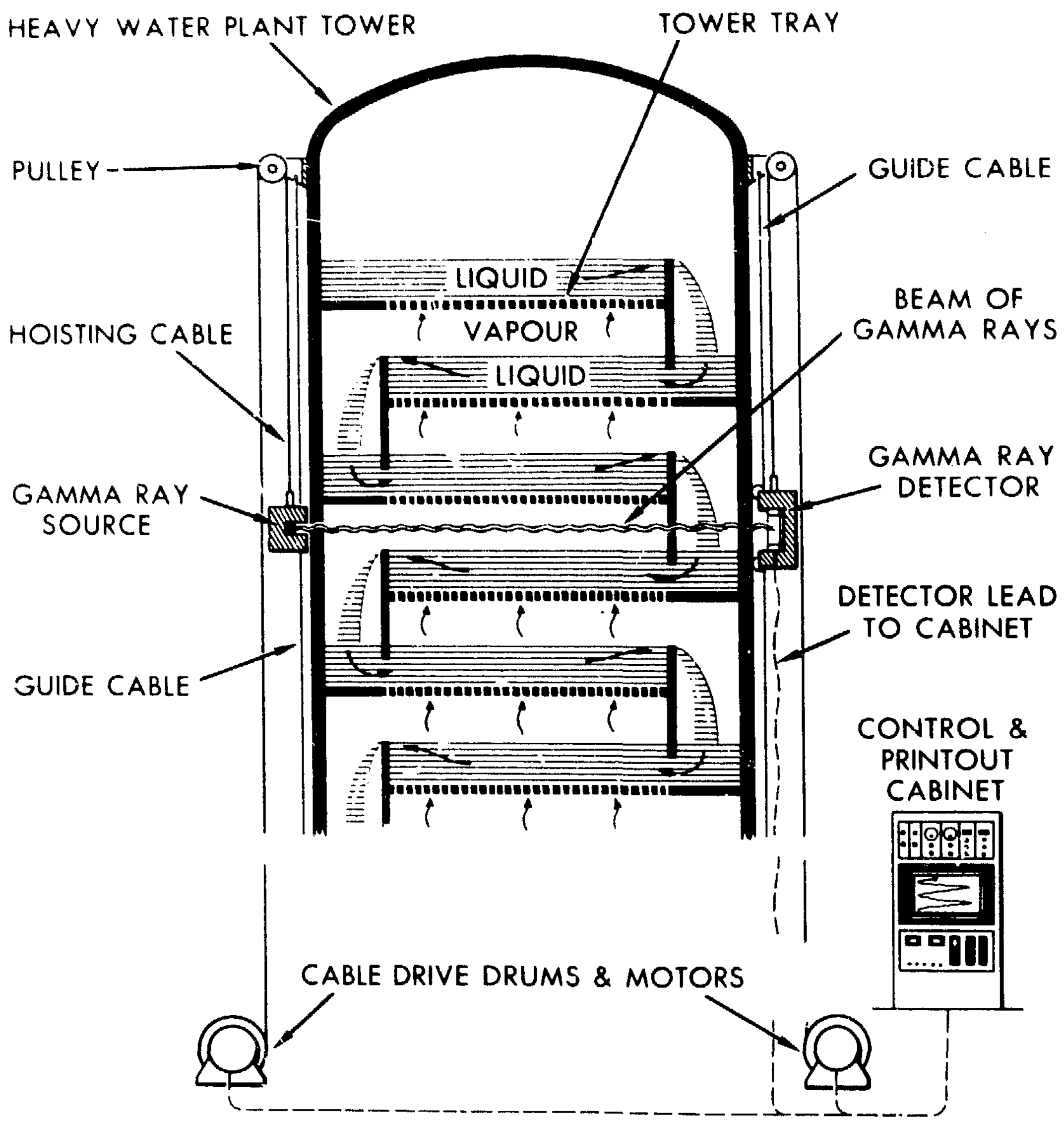
As the source and detector move slowly up or down the Tower, a density profile is traced out on the recorder, see Fig. 10. The peaks represent the relatively low density vapour space between the

Tower trays, and the peak amplitude is a measure of the amount of water present as droplets, dispersed in the gas phase. The very low transmission between peaks is due to absorption of the gamma rays by the tray support structure and by liquid and dense froth above each tray.

Anomalies in the scan pattern may be evidence of internal structural damage. Broken trays do not support their normal levels of water and froth. Displaced trays are indicated by abnormal spacing. Flooded trays show little or no transmission peak depending up the degree of flooding. Figure 11 shows typical recorder traces for some normal and abnormal tray conditions. An unexpected bonus was the correlation discovered between progressive blockage of the sieve tray holes with process precipitates, and the amount of water contained in the gas phase. Figure 12 shows Vol. % water in the gas plotted against tray number. The progressive change in slope with time has proven to be a useful guide in planning Tower outages for cleaning.

In a secondary application, the portable gamma scanner has also proven useful for checking liquid levels in H_2S storage tanks, when the conventional level instruments failed; and for detecting condensate levels in vertical steam heat exchangers.

The instrument has proven to be a valuable diagnostic tool for Heavy Water Plants, and its usefulness could be extended to other industries where process problems require on-line investigation and diagnosis.



SIMPLIFIED DIAGRAM OF GAMMA SCANNER ARRANGEMENT

FIGURE 1

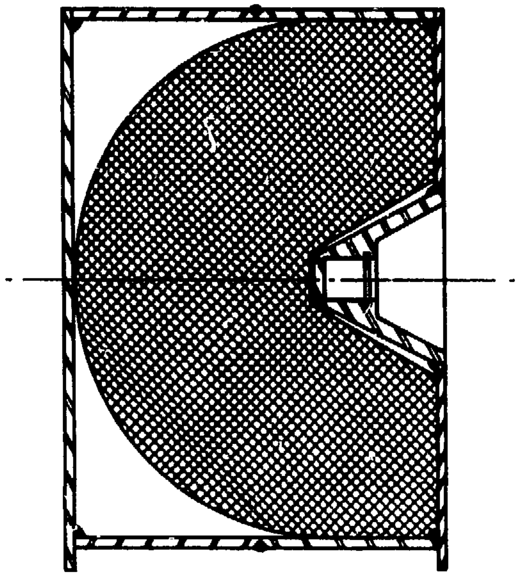


FIGURE 2

SOURCE MOUNTING

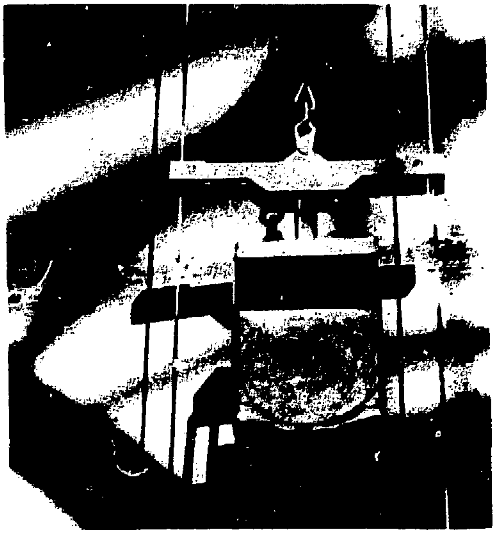


FIGURE 4

SOURCE CARRIAGE

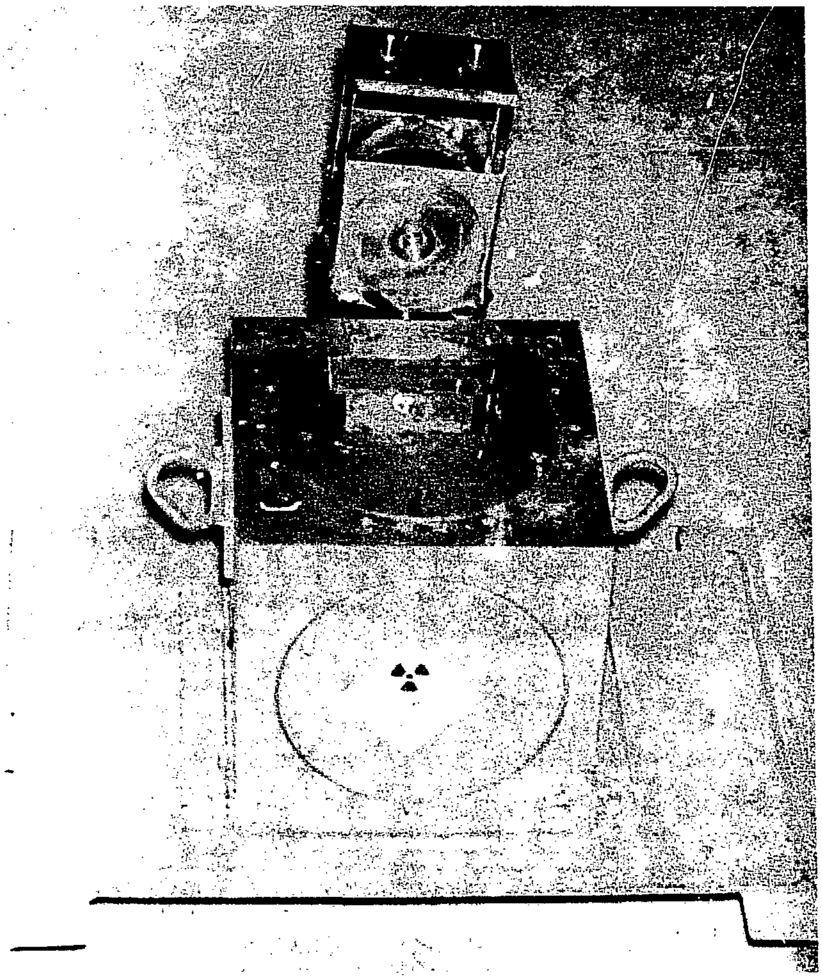


FIGURE 3

SOURCE FLASK

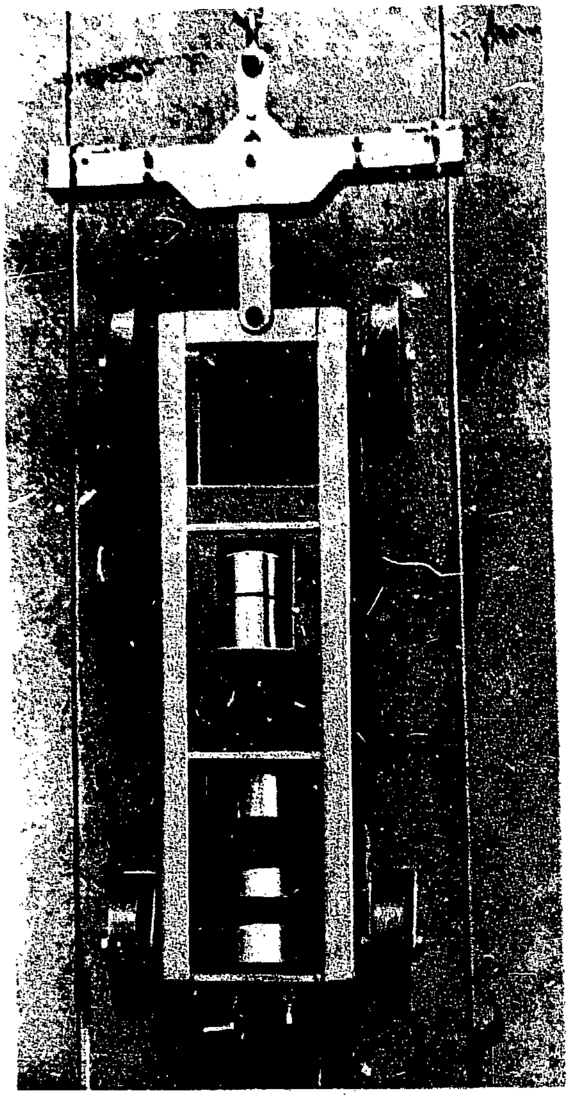


FIGURE 5

DETECTOR ASSEMBLY

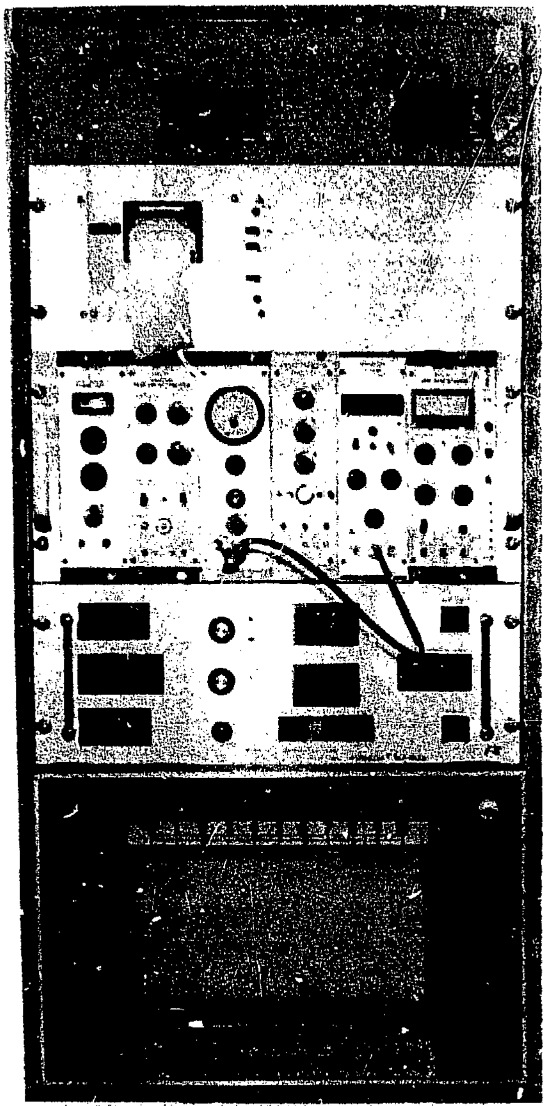


FIGURE 6

ELECTRONICS CABINET

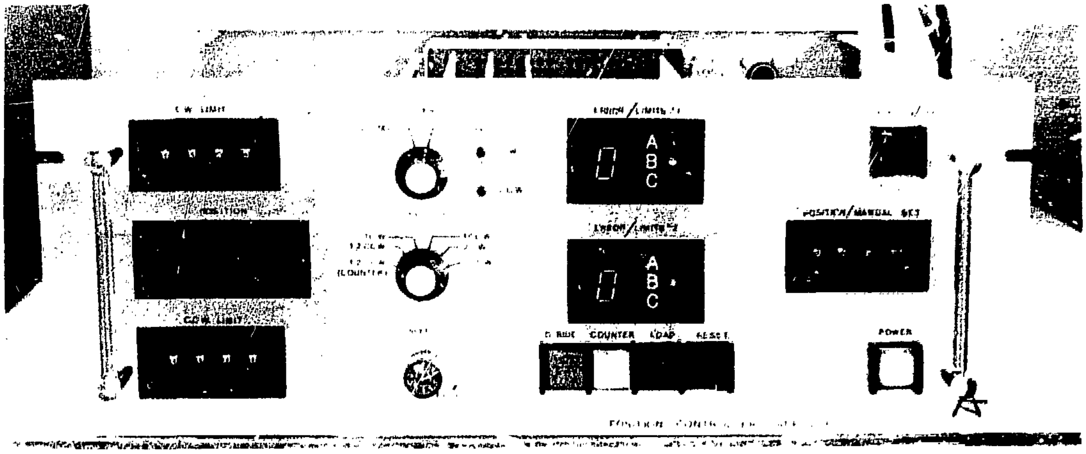


FIGURE 7

CONTROL UNIT

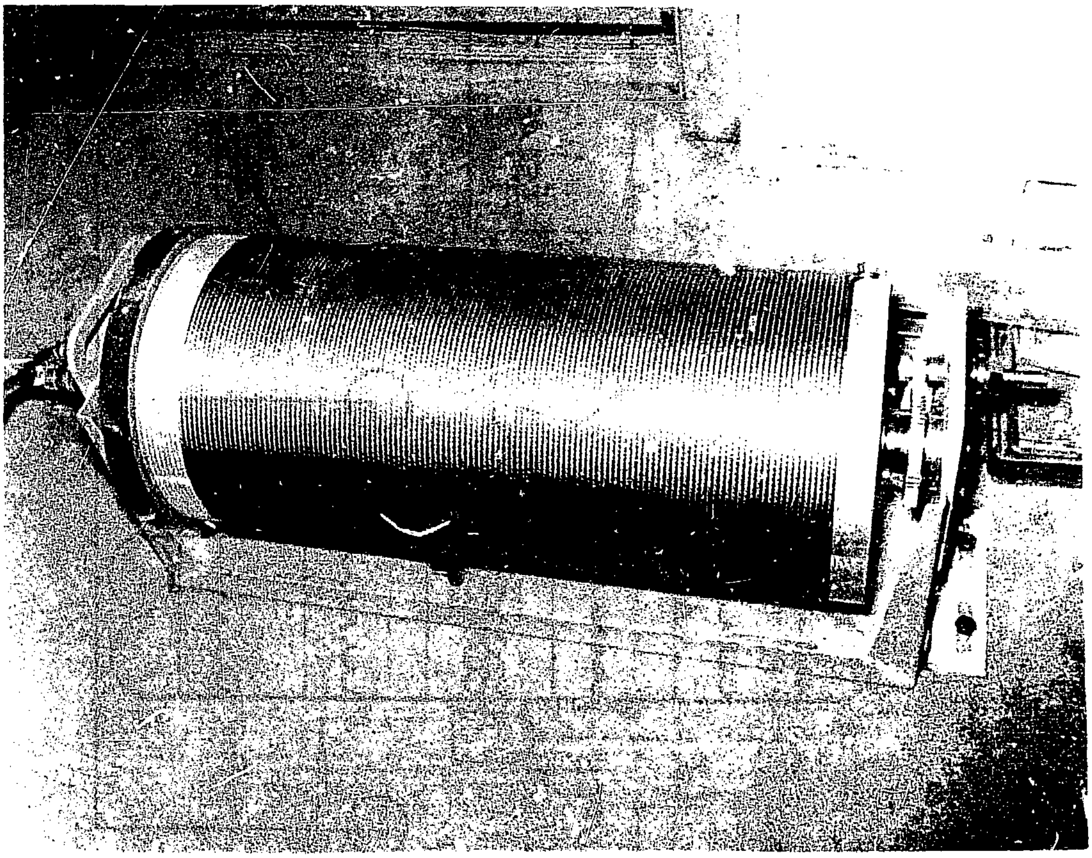


FIGURE 8

MECHANICAL DRIVE UNIT

PORTABLE GAMMA SCANNER
BLOCK DIAGRAM

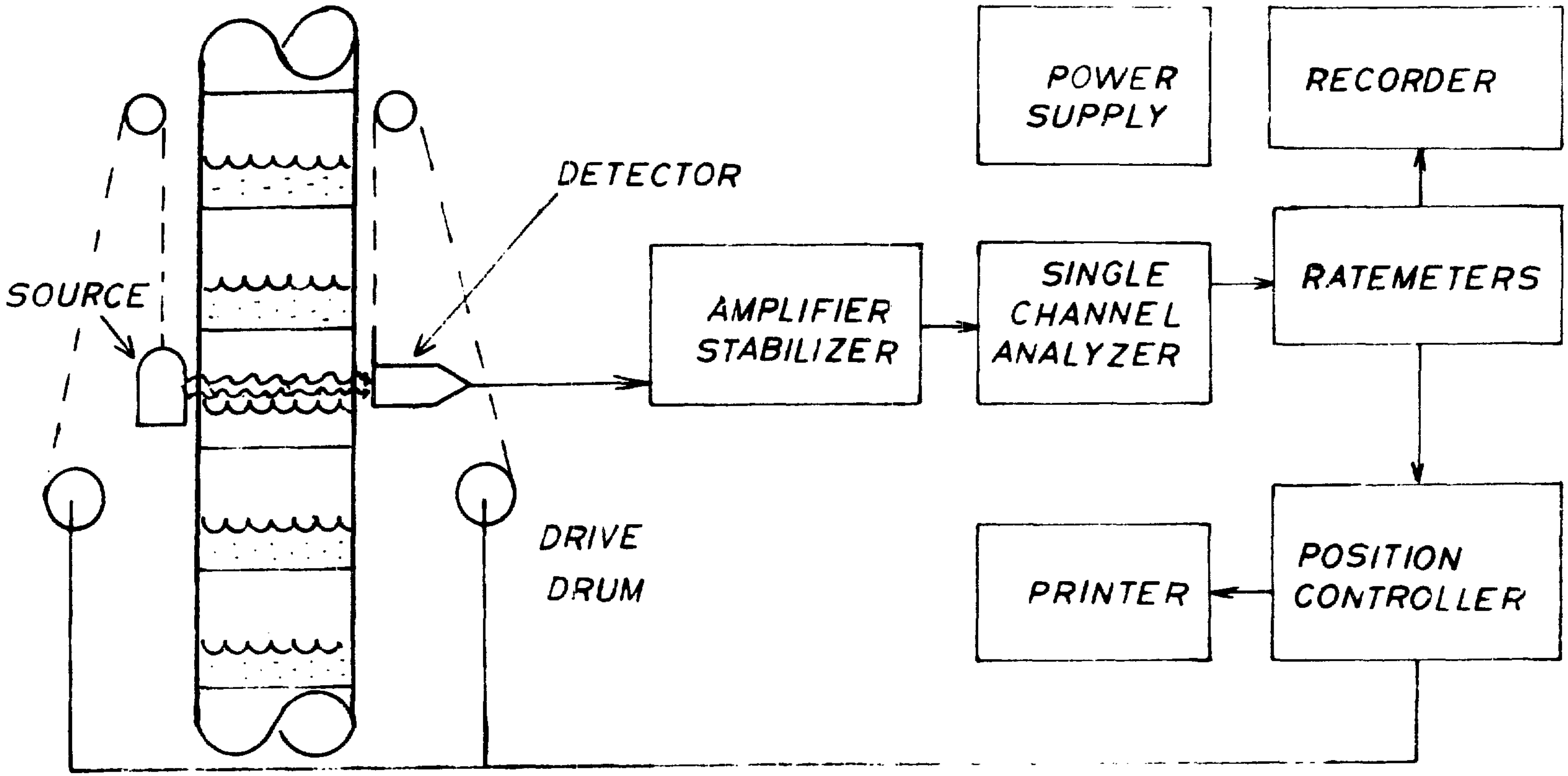
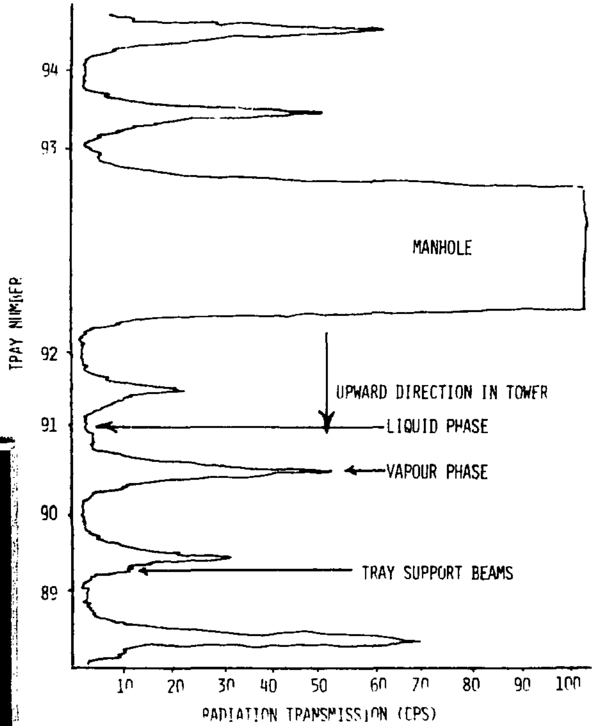
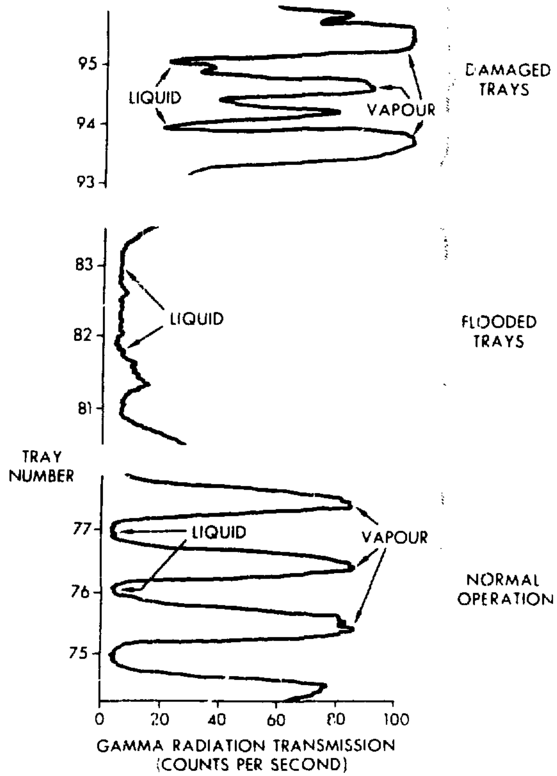


FIGURE 9



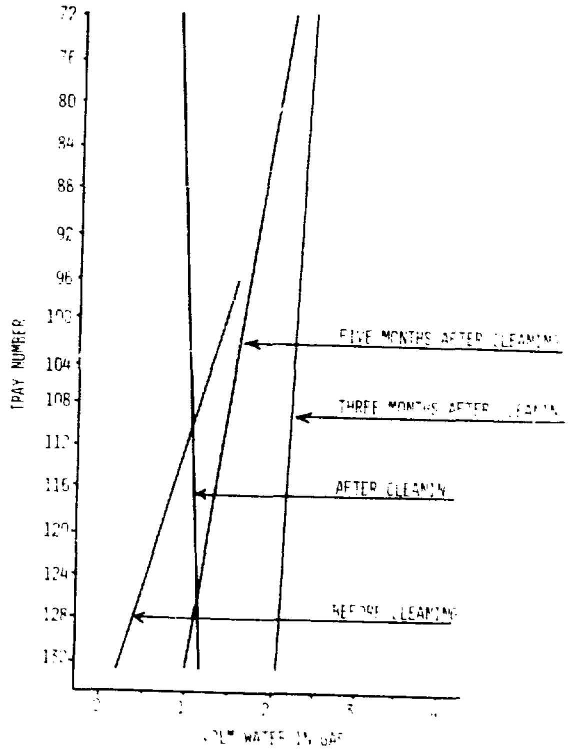
GAMMA SCAN OF OPERATING TRAYS

FIGURE 10



TYPICAL GAMMA SCAN RECORDS SHOWING NORMAL & ABNORMAL CONDITIONS IN AN OPERATING TOWER

FIGURE 11



WATER CONTENT OF GAS VS TRAY NUMBER

FIGURE 12

The International Standard Serial Number

ISSN 0067–0367

has been assigned to this series of reports.

To identify individual documents in the series
we have assigned an AECL–number.

Please refer to the AECL–number when
requesting additional copies of this document
from

Scientific Document Distribution Office
Atomic Energy of Canada Limited
Chalk River, Ontario, Canada
K0J 1J0

Price $2.00 per copy

114-76