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Progress Report on The Application of

Channel Electron Multipliers to

Scanning Electron Microscopy

by

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1. Introduction

Preliminary results using channel electron multipliers (supplied by Mullard) have been reported elsewhere (1). This note described how high resolution, low noise micrographs could be obtained using low beam currents, and also showed that the bandwidth of the system was severely limited. In fact, line speeds of the order of .2 secs had to be employed. This report briefly describes current work on the development of a cathodoluminescence collection system using channel electron multipliers to provide concurrent topographic information. Two multipliers are incorporated in order to investigate the possibility of obtaining compositional information by the addition of the two signals.

2. The Cathodoluminescence Module

Figure 1 shows a drawing of the essential components of the system. The main module block (shown split into halves) is mounted on the specimen stage frame (2) above the normal specimen mounting position. The specimen stage shown in figure 1 is fitted into this position so that it can be moved by the normal, x, y, z and rotation controls. This specimen stage moves inside a polished spherical cavity in the module into which two channel multipliers protrude from slots in the main block. These multipliers are connected to insulated contacts on the rear face of the block, two contacts per multiplier. These contacts mate with similar spring contacts mounted at the rear of the specimen chamber as the stage is pushed home. Leads are taken from these spring contacts to the outside of the chamber via ceramic/metal seals. The preamplifiers (one shown in Fig. 1) are mounted immediately outside the chamber together with the E.H.T. capacitors. This simple capacitor coupled circuit has removed the high frequency response problem at the expense of the low frequency response. The high frequency response is such that 'normal' i.e. 1msec line speeds can now be used with no loss of resolution. The loss of low frequency response due to the coupling capacitor poses no problems, for when slow line speeds are needed e.g. using a pen recorder, then a chopped beam can be used. Two channel multipliers are provided in order to evaluate the possibility of obtaining compositional information by adding the two signals, the topographic information being obtained by subtracting the signals. A similar method was used by Kimoto and Hashimoto using diode detectors (3). A circuit of the add/subtract unit is shown in Figure 2. In the 'add' position, the signals are summed by amplifier A2, whilst in the 'subtract' mode one signal is inverted using A1 before addition in A2. The potential of the 'input' end of the multiplier is varied by means of a simple battery power supply (Fig. 1). Using this type of system, high resolution, low noise micrographs have been obtained using fast line speeds or using slow line speeds and a chopped electron beam.

One of the major problems associated with the collection and detection of cathodoluminescent radiation from scanning beam instruments is that the 'source' of the radiation moves as the beam scans. This movement, together with the magnification associated with any simple light collection system means that large area detectors must be employed. This is not too serious in the visible spectrum where photomultipliers can be used (variations in photocathode efficiency could give rise to spurious signals however). The problem is more acute in the infra-red spectrum where small area semiconductor detectors must be used or when dispersive studies using a spectrometer are required. One solution is to use a conical internally polished light guide (see Fig. 1) in conjunction with one or more lenses. This enables the near perfect but moving point course of radiation to be replaced by a less perfect but stationary source, i.e. the small end of the cone. For non-dispersive studies the infra red detector (InAs 1 mm^2 photo-diode) is placed close to the output end of the cone (see Fig. 1). In the case where a spectrometer is used, an additional lens collects radiation from the end of the cone and matches the radiation into the acceptance angle of the spectrometer. This system is straightforward in the visible spectrum, however, beyond $\sim 2\mu$, special lens material must be used e.g. sapphire.

3. The Final System

The system, when finally completed will do the following:

1. Provide high resolution topographic information.

2. Evaluate channel multipliers as a means of detecting compositional variations.

3. Provide dispersive and non-dispersive cathodoluminescent information over the spectral range $.4\mu$ to $\sim 4.5\mu$.

4. Allow moderate heating and cooling of the specimen ($77^{o}K$ - $400^{o}C$).

5. Allow visual examination of the specimen by replacing the detector system and/or spectrometer with the long working distance optical system already designed.

6. The normal charge collection signals can also be investigated.

References

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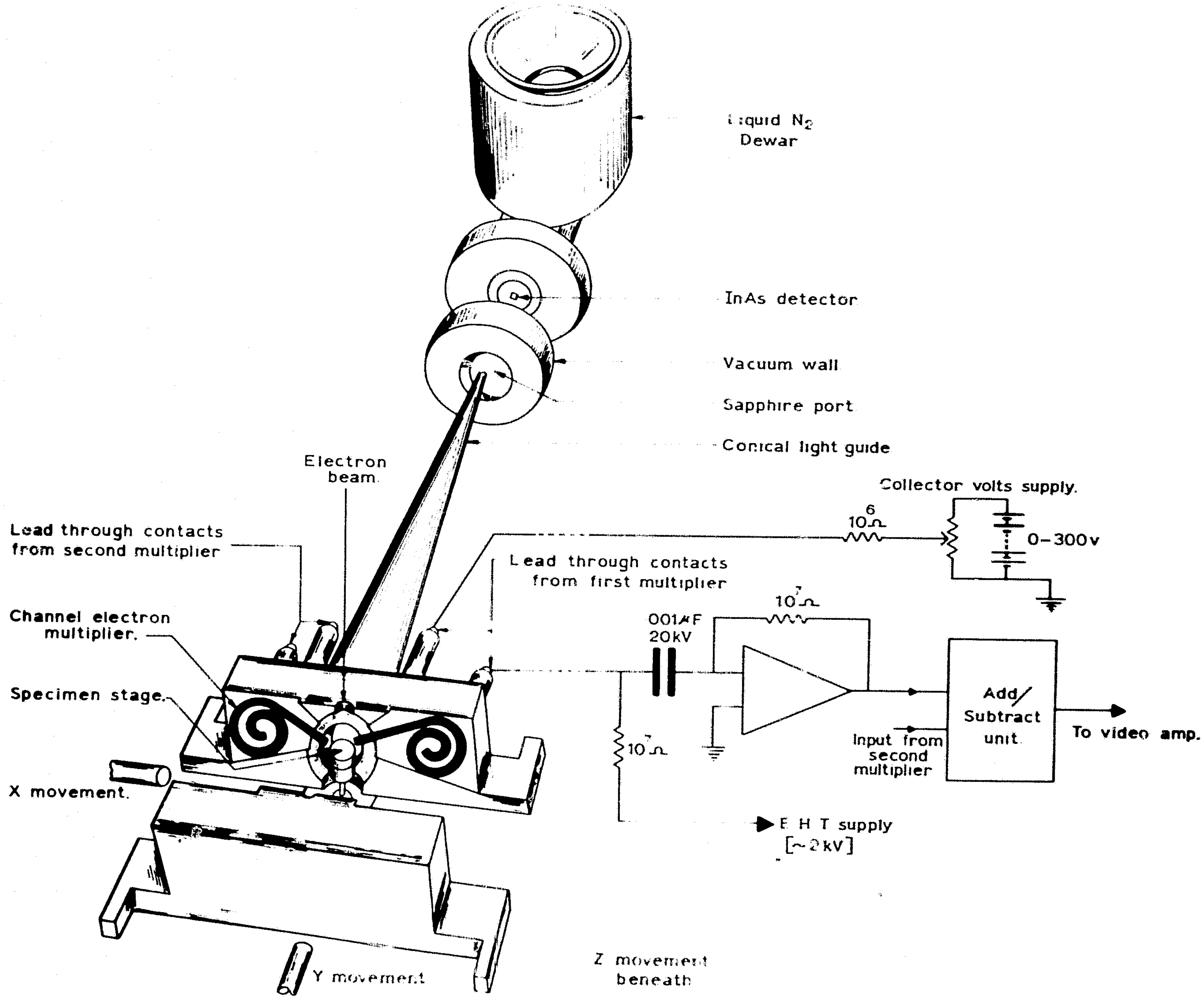
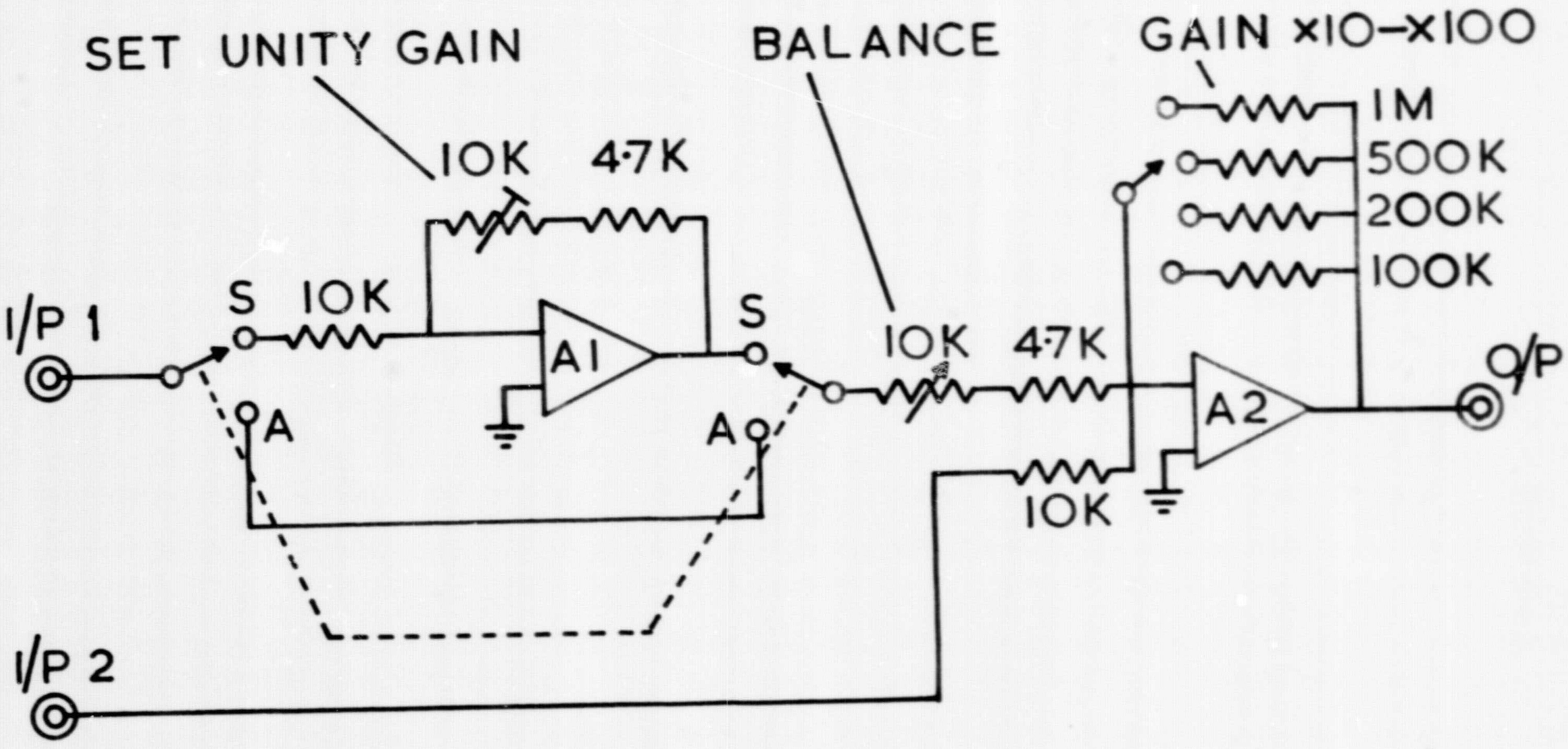


Liquid N_2 Dewar
InAs detector
Vacuum wall
Sapphire port
Conical light guide
Electron beam.
Collector volts supply.
$10^6\Omega$
0–300v
Lead through contacts from second multiplier
Lead through contacts from first multiplier
Channel electron multiplier.
Specimen stage.
X movement.
$10^7\Omega$
001μF 20kV
$10^7\Omega$
Add/ Subtract unit.
Input from second multiplier
To video amp.
E H T supply [~2kV]
Y movement
Z movement beneath

FIGURE I



SWITCH POSITIONS

S – SUBTRACT

A – ADD

FIGURE 2