A VERY SIMPLE DIGITAL MICRODENSITOMETER-COMPARATOR

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In contrast to the preceding contributions on sophisticated and expensive measuring machines this paper is meant to be a poor man's guide, intentioned for those people who use an old-fashioned microdensitometer to analyse stellar spectra, who have only a modest electronics workshop and who would like to take part in the digital era without being able to spend much money or effort.

At Utrecht, we found ourselves in that position five years ago when we had to digitise a variety of solar and stellar spectrograms and could not wait for the completion of the VAMP machine that was then on order. We therefore modernized our old Moll-type microdensitometer in we think about the simplest way possible and obtained a quite useful instrument. We never published this since similar instrumentation had been described already, for instance by the Frascati group (Gratton et al., 1971) and, most extensively, by Hoekstra (1969). However, we received quite a few requests for detailed information on our instrument, so it seems worthwhile to describe it as a do-it-yourself recipe of how to modernize in a practical way old-type instruments used for tracing stellar spectrograms.
The microdensitometer may be of any type or construction provided it has a detector that monitors the transmission or density of a spectrogram while this is moved continuously through the measuring beam. The first step is to have simultaneous digital recording beside the paperchart recorder. The budget choice is between papertape and magnetic cassette or cartridge tape, depending on what the off-line computer to be used can read. Papertape still has many advantages, especially that the punched information can be checked by eye when things go wrong. But punching is slow and large reels of papertape are difficult to handle. One should use the most

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compact output format possible: one 8-bit character for each density measurement. The simplest way is to punch the output of an 8-bit binary analog-to-digital converter ("ADC") that samples the detector signal. The maximum resolution so obtained is 1:256 or 0.4%. Although this is rather bad, it is sufficient since the noise due to plate grain is usually worse. However, since cheap 10-bit ADC's are now abundant (in contrast to five years ago when we had to build our own 8-bit ADC), we would now sample in 9 or 10 bits but still use papertape and punch only the lower 8 bits. The operator would then have to determine from the simultaneous chart recording in which half or quarter of the full range a scan started and the software that reads the tape would have to keep track of cross-overs into other zones. This way of increasing resolution without sacrificing compactness is possible because stellar spectrogram traces are continuous.
The compact output format also permits scanning speeds that are much higher than obtainable with a chart recorder or a curve follower. We use a 120 character/s punch and work with a scanning speed of 100 samples per second. For tracing stellar spectrograms this proved fast enough: usually setting-up takes more time than the actual scanning.

We now turn to positional accuracy. Often expensive high-accuracy screws and stepping motors are installed to drive the plateholder in high-precision steps.This is not necessary since to obtain high positional accuracy in the samples there is no need to position the plateholder itself exactly but only to know precisely where it is. Therefore it is simpler to attach an accurate linear position encoder to the plateholder and to use its position read-out to trigger the ADC at the desired sampling intervals. In this manner one samples "on-the-fly": while the spectrogram moves continuously through the measuring beam, samples of the detector signal are picked at the moments the proper positions pass the detector.
We selected an encoder that consists of an etched nickel-in-glass grating with an optical monitor[0] . We use the change-over of the last digit of the position display to trigger the ADC and we automatically suppress punching at the beginning of a scan until the zero position comes along. In this manner a simple but accurate comparator is obtained: all parallel scans through the stellar spectrum and the comparison arc spectra are started somewhere

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[0] We used a 2 μm resolution Heidenhain grating and monitor head (Joh. Heidenhain, 8228 Traunreut, W-Germany). These optical encoders do not need special precautions and are reliable and easy to use. However, the accompanying Heidenhain position display is expensive and not easily interfaced; we can supply diagrams to build one instead.
A more modern alternative is the steel rule magnetic encoder supplied by Sony Magnescale Inc. (Tokyo 141, Japan).