Direct Analysis of Spectra by Image Isocon and Computer

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Astronomical spectra are, with few exceptions, still being recorded on photographic emulsions. These generally have the advantages of better spatial resolution and larger available area than existing photoelectric imaging detectors. On the other hand they do suffer from a small dynamic range (15 or 20 : 1), reciprocity failure, and a quantum efficiency of less than 1 per cent. Image intensifiers and image

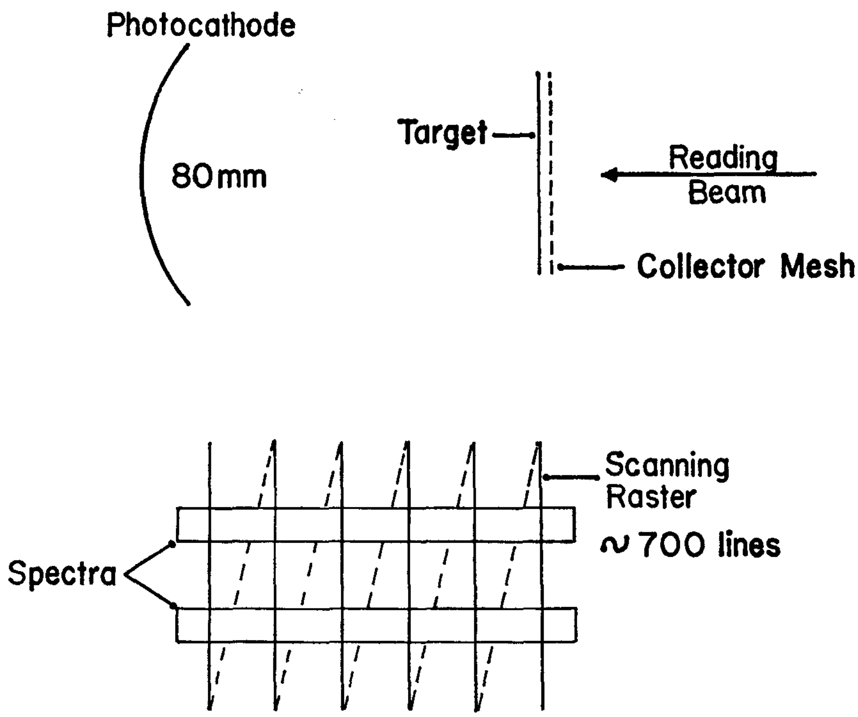

Fig. 1

orthocons can be used to improve sensitivity, but where photographs are used for the record the other problems tend to remain. Calibration and extraction of the appropriate astronomical information in digital form involves a considerable amount of time and careful work, as one can appreciate from many of the papers presented at this colloquium.

We have developed a system that uses a refrigerated image isocon television camera (English Electric Valve Co., P850) as the detector for an astronomical spectrograph, directly digitizes the camera output, and stores the results on magnetic tape. The action of the isocon, and the P850 in particular, has been described by P. D. Nelson (1969). It has an S-20 spectral response with a peak quantum efficiency of about 10 per cent, a resolution of about 0.1 mm, and a linear response over a dynamic range of at least 200 : 1. Light falling on the photocathode releases photoelectrons which are accelerated and focussed onto a thin glass target. Secondary electrons released from the target are collected, leaving a positive charge distribution resembling the optical image on the photocathode. A beam of electrons scans the target. Some of the beam lands, neutralizing the target, and some electrons are scattered and collected and amplified in a dynode chain. The varying output current of the dynode chain is thus directly proportional to the target charge distribution.

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Two spectra (sky, sky and star) will be imaged on the photocathode, which is 80 mm in diameter, and there are some 700 lines in the scanning raster, which is normal to the spectra. This is shown schematically in Figure 1. The system will be equivalent to a 1400 channel photometer. A closed, forced air, convection cooling system is used with the air circulating in the space between the coils and the tube. Refrigeration below 0°C allows target integrations (*i.e.* build up of charge at the target before read out) in excess of 100 sec without loss of resolution due to charge spread.

Integrations are achieved by blanking the reading beam for a preset number of frames according to the scheme shown in Figure 2. Readout lasts 1/40 sec, and while the reading beam is crossing a spectrum one of two integrators is opened and the integrated voltage is digitized by a 12-bit 120 kHz analog to digital converter. This scheme is shown in Figure 3. The output of the ADC is stored by

Control of Isocon Target Integration

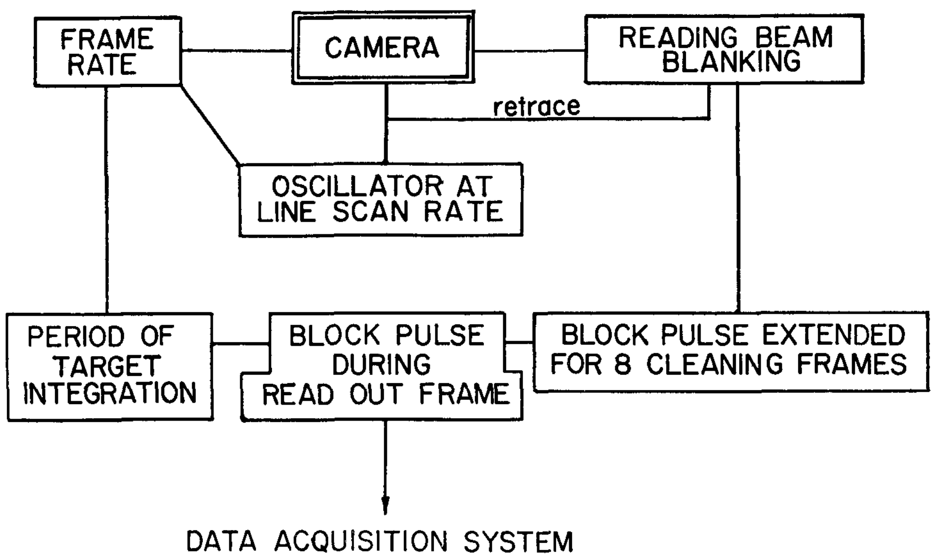

Fig. 2

direct memory access in the core memory of an Interdata Model 4 computer. After the read out frame is complete the 1400 words of data are transferred to IBM-compatible magnetic tape and the data is monitored from core on an oscilloscope. The block diagram is shown in Figure 4. After cleaning the target for several further frames another target integration can begin.

Running means and the differences of the two spectra can also be taken and displayed during exposures and a more detailed analysis can be carried out when sufficient frames have been accumulated to give an adequate signal to noise ratio. The whole system was largely complete at the time of the colloquium.

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REFERENCE

Nelson, P. D., 1969. *Advances in Electronics and Electron Physics*. ed. by J. D. McGee, D. McMullen and E. Kahan, Vol. 28A, p. 209. London: Academic Press.

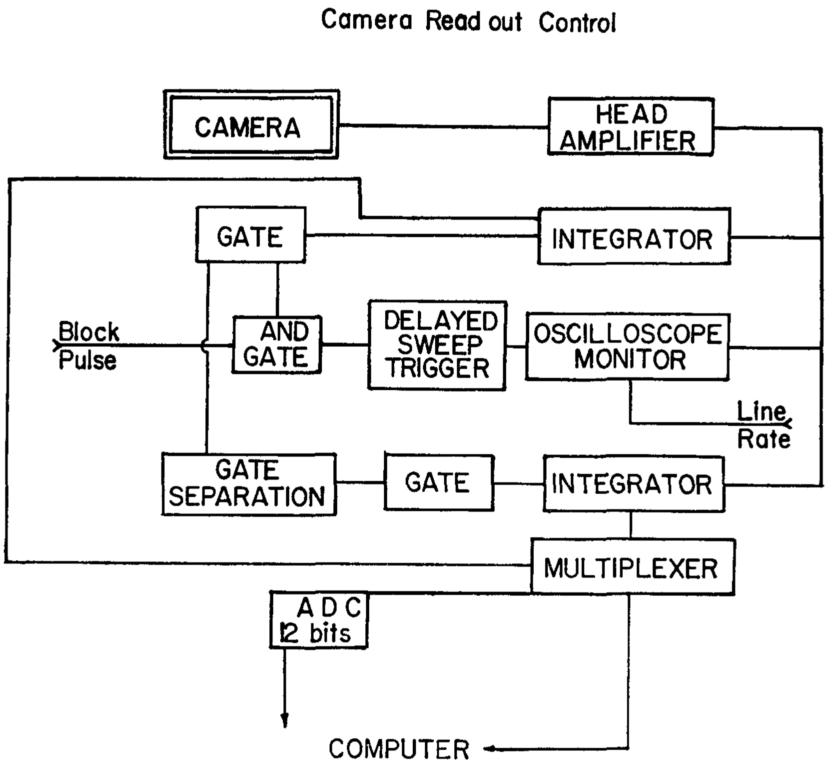

Fig. 3

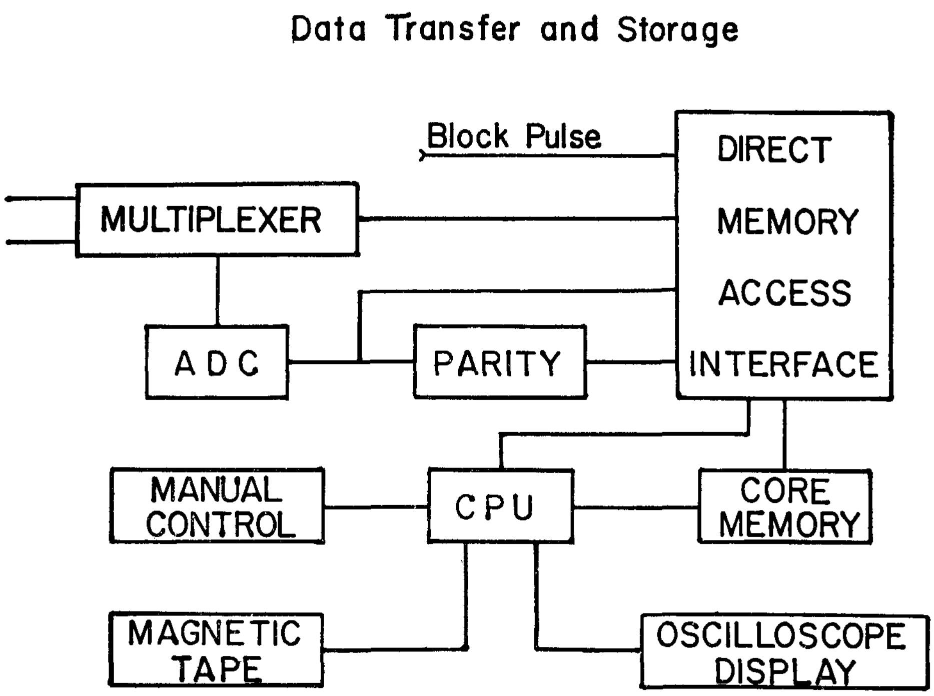

Fig. 4

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DISCUSSION

M. J. CULLUM: What is the size of the photocathode, and the resolution of the system referred to the cathode?

G. A. H. WALKER: Cathode diameter is 80 mm, so a square raster would be smaller than this. The resolution is about 0.1 mm.

R. B. DUNN: Does the beam noise limit the signal-to-noise at readout? How long can you integrate before readout in order to improve the signal-to-noise?

G. A. H. WALKER: Beam noise is the dominant noise source. The commercial dynamic range of the tube is 2000 : 1, but the linear range is only 200 : 1. We integrate the maximum light level up to the limit of the linear dynamic range. So we have to set the integration time for each star, and in the case of emission lines, for instance, we have to cut the exposure down. To go further, we add frames in the computer, and because we want to resolve the noise, we're going to 12 bits.

W. A. DEUTSCHMAN: How do you intend to handle the variation in sensitivity of the target over its face when you add the spectra? We found that different areas in the target of an SEC tube had different transfer curves. If you want to add, you must take the transfer curves out before adding.

G. A. H. WALKER: We're side-stepping this by using the same areas of the photocathode for the spectra. A negative cylindrical lens spreads both spectra normal to the dispersion sufficiently to avoid significant motion of the spectra through guiding errors. We shall also be using a calibration source.

E. W. DENNISON: What would be the effect of adding an image intensifier?

G. A. H. WALKER: It seems to me that there would be a rather severe calibration problem. The quantum efficiency of the image intensifier is no better than the camera. You would have to read out more frequently so you have more beam noise. Where the balance is I'm not quite sure at the moment; if you had a very good image intensifier it probably would be an advantage, but flashes or phosphor spread or persistence I think could severely restrict the whole thing.