An Extinction Scale-Expansion Unit for the Beckman DK2 Spectrophotometer

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The paper describes a simple but accurate unit for the Beckman DK2 recording spectrophotometer, whereby any 0.1 section of the extinction ('absorbance') scale may be expanded tenfold, while preserving complete linearity in extinction.

For the biochemist, a recording spectrophotometer is probably of greatest value for following chemical reactions by plotting changes of extinction ('absorbance' or 'optical density') against time at a fixed wavelength. Many biochemical reactions, however, involve starting materials with a fairly high extinction and produce relatively small changes in this extinction. For such cases it is of great value to be able to expand at will any section of the extinction scale (e.g. the section 0.6–0.7) to fill the whole height of the chart, so as to increase the slope of the reaction curve.

Some commercial spectrophotometers can be fitted with scale-expansion attachments for this purpose, but they tend to be somewhat complicated and expensive, and to require several adjustments to bring them into operation. Some cover only a limited range of the scale.

The widely used Beckman DK2 (DK2A) recording spectrophotometer has no such scale-expansion facility. The commercially available scale-expansion unit for the Beckman DB instrument expands the percentage-transmission scale, not the extinction scale, and does not solve the problem for the following reason. Chemical changes are proportional to extinction changes, not to transmission changes. The multiplication of the percentage transmission by a constant factor is merely equivalent to the addition of a constant quantity to the extinction; a tenfold expansion of the percentage-transmission scale is equivalent to the addition of 1 to the extinction scale, and this leaves the slope of the time curve unaltered. In any case, the Beckman DK2 instrument already has provision for the addition of 1 to the extinction scale.

A circuit similar to that of the Beckman DB expansion unit could be used merely to expand any section of the extinction scale by multiplying by a constant factor the corresponding range of the logarithmic voltage delivered by the signal ampli-

fier. But this would give a scale not linearly related to the extinction; moreover, the properties of the logarithmic scale are such that the degree of non-linearity would be different for the different sections of the extinction scale. The problem can, however, be solved in a different way; and this paper describes an accurate but cheap and easily constructed unit for the Beckman DK2 instrument. This unit, by the turning of a single knob, allows any 0.1 section of the extinction scale to be brought to fill the whole chart of an auxiliary ('slave') recorder, while preserving complete linearity in extinction throughout the whole range from 0 to 2. Thus, if the slave recorder has the same chart size as the Beckman DK2 instrument, the unit gives a fixed tenfold scale expansion. The device has given a very satisfactory performance during two years of almost constant use.

Principle. The Beckman DK2 instrument contains two potentiometers mechanically linked to the pen drive; these generate the voltage, determined by the position of the pen, which is applied as a feedback signal to the pen servo mechanism. One of these potentiometers is linear and is used for transmission measurements; the other is logarithmic and is used for extinction measurements. The control knob of the Beckman DK2 instrument switches the pen control from the linear to the logarithmic potentiometer when changing from 'T' (transmittance) to 'A' ('absorbance'). The linear potentiometer, however, is not left idle during 'absorbance' (extinction) measurements, for a very much higher voltage is then switched across it, and the variable voltage that it then delivers is applied as a gain-controlling bias to the pen servo amplifier, to give the proper sensitivity for control of the pen movements in different regions of the extinction scale. Since, when switched to 'A', the movement of the pen is linearly related to the extinction, and since the linear potentiometer is mechanically coupled to the pen,

sions then correspond to an extinction of 0.1; thus if the switch is turned to 0.6 and the recorder reads 35 divisions the extinction is 0.635.

Operation. This is extremely simple. The knob of the unit is conveniently kept at 'OFF', which short-circuits the slave recorder, and to bring it into operation the knob is merely turned up until the pen of this recorder moves on to its scale.

The slave recorder simply follows the movements of the pen of the Beckman DK 2 instrument. It is unaffected by the 'zero' and '100%' controls of the Beckman DK 2 instrument, except insofar as maladjustment of these may cause the pen to give an incorrect reading. For the same reason the unit works equally well for the extinction range 1-2; it is merely necessary to add 1.0 to the readings, as in normal use of the Beckman DK 2 spectrophotometer.

Since there is a tenfold expansion it might be expected that amplifier 'noise' would be increased tenfold. This is not the case; there is in fact very little noise, even with the shortest 'time constant' of the Beckman DK 2 instrument. 'Noise' will not get through to the recorder unless it is sufficient to cause an appreciable movement of the pen of the Beckman DK 2 instrument, and for this reason any high-frequency background is almost completely damped out. In the unlikely event of dirt

being present on the potentiometer contact, sharp downward spikes may be recorded while the pen is moving slowly. These spikes, which do not affect the curve, may be largely removed by putting a suitable capacitor across the recorder.

Cost. The cost of the unit is very small, the main expense being the cost of the slave recorder. Many Laboratories, however, will already have recorders available. [The recorder must not draw an appreciable current from the unit. A most suitable type is one with a vibrator input, such as the HiSpeed Miniature Recorder (Control Instruments Ltd., Derby) or the more expensive Honeywell Electronik High Speed Recorder, Honeywell Controls Ltd., Brentford, Middlesex). I have used mainly the former instrument; although it has only a 6in. chart, it has the advantages of portability and of interchangeable plug-in range units, of which that for 0-1mv should be chosen.] Against the cost of this recorder, if a new Beckman DK 2 spectrophotometer is being purchased it is possible to offset the cost of the time-drive accessory of the Beckman DK 2 instrument, for this may be dispensed with if a switch is provided to substitute for R_4 a resistor of one-tenth of its value. This enables the scale-expansion to be switched off at will, and then all time-recording can be done on the slave recorder, with the knob of the unit set at 0.