

Magnetic Tape Recording of Analytical Data

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Merritt (2) has reported the use of magnetic tape for recording mass spectra derived from a rapid scanning time-of-flight mass spectrometer, and concurrently with this communication the recording of fast scan high resolution mass spectra is reported (3). This communication describes the technique employed for recording multiple fast scan mass spectra of compounds separately eluted from a gas chromatographic column and elaborates some of the advantages of magnetic tape in modern analytical data acquisition and processing.

The versatility of magnetic tape is a consequence of the fact that electrical signals are recorded essentially in electrical form. They may be reproduced at some future time at faster, slower, or the same tape speed used for recording the signal. This time scale expansion and compression feature can facilitate interfacing of analytical instruments to data acquisition systems which provide digital records suitable for computer processing. Data recorded in a variety of time frames may be matched, via analog magnetic tape, to a single digitizing system, reducing the complexity and cost of such systems.

Magnetic tape recorders are available with a variety of features, degrees of sophistication, and costs. The specific

instrument needed obviously depends on the requirements of the laboratory. Most instrumentation class recorders offer tape speeds of $1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$, 15, 30, and 60 inches per second (i.p.s.). Tape speed accuracy between 0.2 and 0.5%, and flutter (short term tape speed deviation) between 0.2 and 1.0% are typical of lower price instrumentation recorders. Since recorders may be purchased with seven to fourteen available data channels, it is usually feasible to utilize one channel for recording an accurate timing signal. Oscillators or pulse generators of any frequency and degree of accuracy may be employed depending upon the timing accuracy required in analysis of the data. Thus, an internal standard is provided which makes time measurements essentially independent of tape speed. Independent variables other than time, such as magnetic field strength, voltage, or temperature may also be employed in this manner.

Full scale signal to noise ratios of 40 db. (100:1) are typical of instrumentation recorders operating in the FM mode. This limitation on the dynamic range of the recording system is not serious if the multiple track recording capability is utilized with each track receiving a signal at different attenuation or gain level in a manner similar to that employed with mass spectrometer oscillographic recorders. High speed automatic attenuators may be

used to extend the dynamic range for single channel recording.

Magnetic tape recording alleviates many of the data handling problems associated with mass spectrometric analysis of gas chromatographic effluents. If one wishes to identify the maximum number of components of a complex mixture of volatile compounds, a large number of spectra—e.g. 200 to 300—must be recorded during the chromatographic separation. Often many preliminary preparation steps are required to obtain a suitable sample; therefore, it is desirable to extract as much information as possible from a single sample. The probability of missing a significant compound should be minimized. These considerations require either careful judgment by the operator as to when to record spectra during elution of chromatographic peaks, or continuous scanning of spectra during the entire course of elution. If magnetic tape is used as a recording medium, repetitive mass spectral scanning may be employed and all data are permanently recorded in convenient form. The tape may be played back and spectra may be examined carefully prior to permanent recording in any desired format. Data may be examined using an oscilloscope triggered from a scan start pulse recorded on one tape channel, or a recording oscillograph at a slow chart speed may be used.

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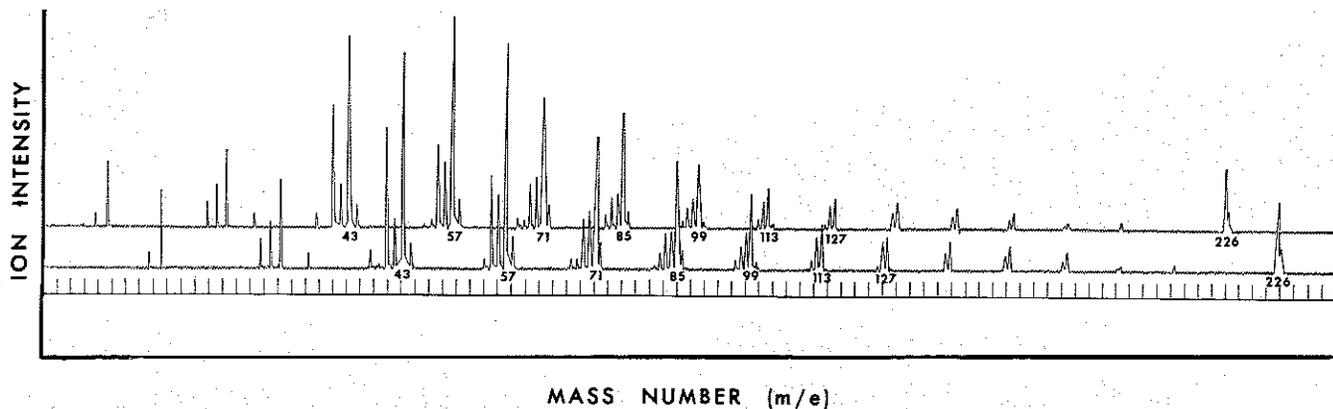


Figure 1. Mass spectrum of hexadecane

Upper trace: Direct oscillographic record
 Lower trace: Reproduction of oscillographic record of spectrum recorded on magnetic tape
 Galvanometer frequency response, 1 kc.
 Oscillograph chart speed, 8 i.p.s.
 Spectrum scan rate, m/e 12-200 in 6 sec.
 Tape speed, $7\frac{1}{2}$ i.p.s.

Figure 1 illustrates the accuracy with which mass spectra may be reproduced by magnetic tape recording. The electrometer output of a Bendix Time-of-Flight mass spectrometer was recorded by both an oscillograph and a magnetic tape recorder (CEC Model VR 3300) operated in parallel. The tape recorder output was displayed on a second oscillograph trace. Displacement between the two hexadecane spectra represents the time required for the tape to move from the record head to the reproduce head. Only one channel of data was recorded in the interest of clarity. The tape was recorded and reproduced in the FM mode at $7\frac{1}{2}$ i.p.s. Oscillograph chart speed was 8 i.p.s.

When differences appear, chart speed may be increased to examine details of the spectrum. Figure 2 was taken from the same tape recorded hexadecane.

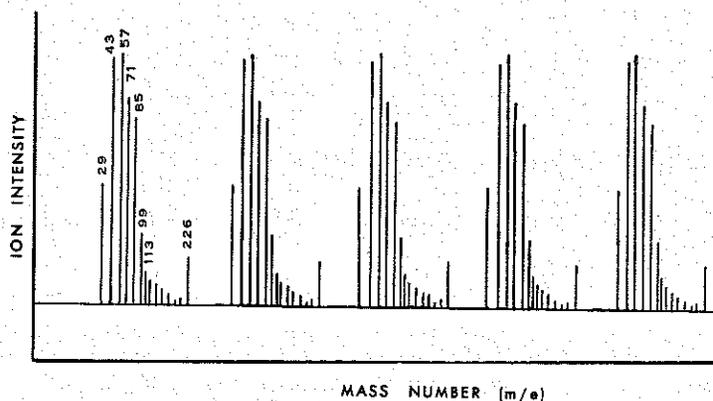


Figure 2. Oscillograph record of five repetitive scans of a hexadecane spectrum recorded and reproduced on magnetic tape at $7\frac{1}{2}$ i.p.s.

Galvanometer frequency of response, 1 kc.
 Oscillograph chart speed, 0.125 i.p.s.
 Spectrum scan rate, m/e 12-200 in 6 sec.
 Timing signal, 250 p.p.s.

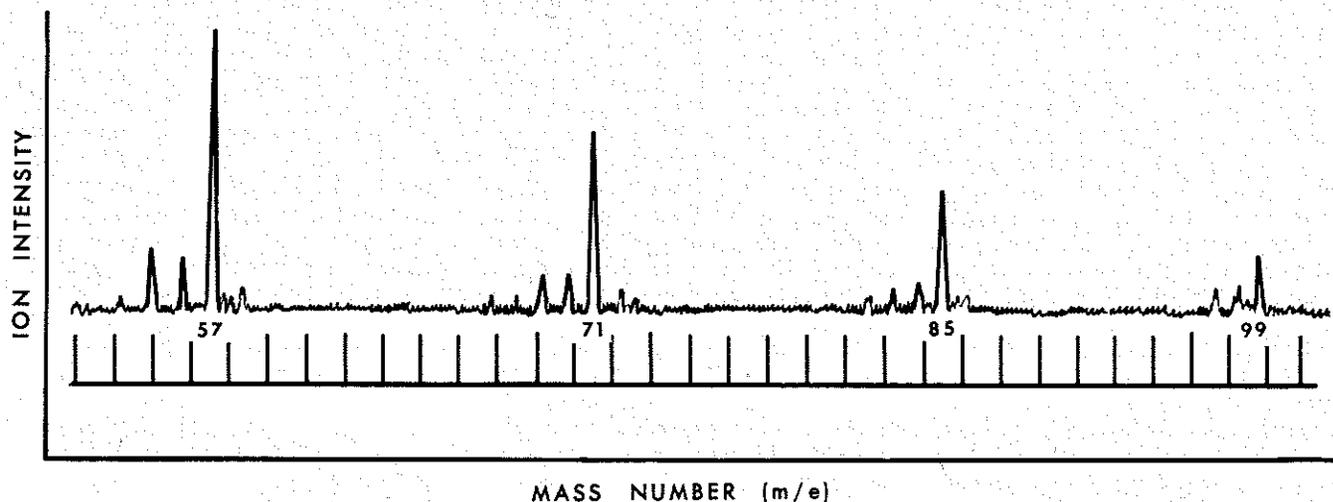


Figure 3. Portion of hexadecane spectrum (m/e 57-99) recorded on magnetic tape at $7\frac{1}{2}$ i.p.s. and reproduced on an oscillograph

Galvanometer frequency response, 1 kc.
 Oscillograph chart speed, 8 i.p.s.
 Timing signal, 250 p.p.s.

spectra as Figure 1, but the oscillograph chart speed was 0.125 i.p.s. At this speed a large number of adjacent spectra may be examined for detection of differences. Figure 3 illustrates the use of this technique for closer inspection of the m/e 57 to 99 region of the same spectra at a chart speed of 8 i.p.s. The scan rate for all spectra was 6 sec. for a range of masses from m/e 12 to 200. The reference timing signal seen at the bottom of each record was generated by a General Radio Type 1217-B pulse generator with a repetition rate of 250 p.p.s.

A chromatogram may be displayed either by recording total ionization on one tape track or by playing back the

tape into a slow response servo-recorder in parallel with the oscillograph as described by Dorsey, Hunt, and O'Neal (1). The latter method provides greater economy of tape track utilization without loss of data.

Magnetic tape provides a simple versatile means for recording large volumes of analog data which must be examined in detail at some time after recording. When the data have been transferred to graphic form or digitized, the tape may be re-used or stored for permanent reference. A more detailed description of a completely automated data handling system for fast scanning mass spectrometers will be the subject of a forthcoming manuscript.

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LITERATURE CITED

- (1) Dorsey, J. A., Hunt, R. H., O'Neal, M. J., *ANAL. CHEM.* **35**, 511 (1963).
- (2) Merritt, C., Jr., Paper presented before 3rd Annual Meeting of ASTM Committee E-19, Houston, Texas, October 1964.
- (3) Merritt, C., Jr., Issenberg, P., Bazinet, M. L., Green, B. N., Merron, T. O., Murray, J. G., *ANAL. CHEM.* **37**, 1037 (1965).