the signal from the detector, and a discriminator eliminating the signals from the alpha particles with low energies. A variable discriminator control makes it possible to select the lightest element to which the instrument is sensitive.

4) Readout system and timer. Each alpha particle entering the detector with an energy above the set threshold is counted by a high-speed decade counter with an integrated circuit and internal memory. The total number of registered alpha particles is displayed on demand on a four-digit light emitting diode display system. A timer built into the instrument automatically stops the measurement after a desired time period.

A practical instrument should be operable in air. Because of the low penetrating power of alpha particles this requires that the distances from source to sample and sample to detector be as small as possible. This is achieved in the design illustrated in Fig. 1. The source is collimated in such a way that it irradiates an area of the sample which is small (about 1 cm^2), but large enough to minimize effects of surface inhomogeneities in the sample. The overall geometry was selected to maximize the solid angle for detection of alpha particles without appreciably degrading the resolution of the instrument by including too large a variation in scattering angle.

Spectra of backscattered alpha particles obtained in a vacuum from pure elements have sharp end points at high energies (*3*). In air the particles lose energy, and the end points are shifted to lower energies and are less sharp. They are, however, still defined well enough to allow a threshold to be set for a particular element.

Figure 2a shows the integrated response of the instrument when examining some carbonates, with three different settings of the threshold. With the lowest threshold the instrument registered alpha particles scattered from all elements heavier than about zinc. The sensitivity of the instrument is high, and lead present even in about 0.1 percent by weight can be detected in a short time in this mode. In the other two cases in Fig. 2a the threshold was set for cadmium and barium.

Most tests with this instrument were made with only two thresholds: low level (set to detect elements heavier than zinc) and high level (set to detect elements heavier than barium). The background in the low-level mode was about 2 counts per minute; in the high-level mode it was less than 1 count per minute.

Table 1. Lead contents in paints on some toys; the results obtained with the instrument described here are compared with the results of conventional analysis (*5*). The measurement time with the alpha detector was 1 minute.

Sample	Lead (% by weight)	
	Alpha scattering heavy element detector	Conventional analysis
1	<0.1	0.08
2	0.1	0.3
3	12, 14.5	17.0
4	4.3	3.5
5	0.6	0.87
6	0.25	0.42
7	<0.1	0.09
8	19	23

The instrument was calibrated (for amounts of heavy elements as percentages by weight) by using a set of paint samples with known amounts of lead ranging from 0.2 to 43.0 percent. Figure 2b shows a calibration curve for the low-level threshold setting. The calibration curve for the high-level setting is similar except for the lower response rate. The response, although interpretable as lead content through the calibration curves, refers, strictly speaking, to the total heavy element content, with a relative sensitivity determined by Fig. 2a.

As a part of the testing of the performance of the instrument, the paints on a number of children's toys (*5*) were surveyed for lead content. Table 1 compares the results obtained with this instrument with those obtained by conventional analysis. This table indicates that measurements made in 1 minute by such an instrument can determine the lead contents of paints in practical situations. As mentioned earlier, the painted surface being examined must be bare; for example, a wax or varnish covering ½ μm thick will decrease the sensitivity for lead by about a factor of 2.

An instrument of the type described here could have many other applications in surface analysis. It would provide relatively rapid, nondestructive measurements of the quality of gold or platinum, and of the thickness and uniformity (in the micrometer range) of certain surface coatings and thin films. Relatively minor modifications could lead to devices for measuring gas densities.

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Huntite Flowstone in Carlsbad Caverns, New Mexico

Abstract. *Huntite flowstone has recently been discovered in Carlsbad Caverns. This flowstone occurs as a thin, white layer of microcrystals (approximately 1 to 60 micrometers in diameter) which appears buckled and crinkled. The huntite is believed to be precipitating directly from magnesium-rich solutions rather than forming by alteration of preexisting minerals.*

Carlsbad Caverns is well known for its abundance and diversity of carbonate speleothems (*1*). Reported secondary carbonate minerals are calcite, aragonite, dolomite, hydromagnesite, and huntite (*2*). Huntite, $CaMg_3(CO_3)_4$, is a rare mineral found previously in caves as moonmilk (*3–5*), and elsewhere in cavities and vugs of magnesite, dolomite, and deweylite (*6*) and in marine evaporites (*7*).

Recently, huntite has been discov-

Fig. 1. Huntite flowstone that has become desiccated, cracked, and subsequently curled along its cracked edges. [Photographed by Pete Lindsley, Dallas, Texas]

ered as a wall flowstone in Carlsbad Caverns, New Mexico. This flowstone is located in a small alcove about 40 m down a side passage continuous with the Lunchroom (*8*). It appears to be forming actively along with a number of tubular stalactites, helictites, and draperies. Moonmilk, which is usually prevalent in the lower portions of Carlsbad Caverns, is noticeably absent along the entire side passage. The huntite flowstone occurs as a chalk-white, microcrystalline layer (1 mm thick) that appears to be buckled away from a more coarsely crystalline flowstone of a different composition. The huntite layer has become desiccated and cracked in places. The edges of the cracked layer have curled so that the total display resembles a mass of cornflakes or Chinese fortune cookies (Fig. 1). The huntite flowstone is approximately 3 m in vertical extent and a maximum of 1 m in width. Individual crystals of huntite measured from 1 to 57 μm, with the most common size in the range of 10 to 20 μm. The huntite was identified by x-ray powder patterns, as were five other minerals in the vicinity. Specifically, the wall bedrock is calcite; some fine powder on the floor approximately underneath the huntite flowstone is also calcite; the more coarsely crystalline flowstone underlying the crinkled huntite layer is dolomite; a light tan flowstone on the opposite wall of the alcove (about 2 m from the huntite flowstone) is calcite; narrow chalk-white ribbons of flowstone overlying the tan calcite flowstone are aragonite.

These carbonate minerals appear to be precipitating directly from solutions containing varying amounts of calcium and magnesium. Minerals which have precipitated from solutions with larger Ca^{2+}/Mg^{2+} ratios are overlain by a mineral which has precipitated from solutions with lower Ca^{2+}/Mg^{2+} ratios, namely, huntite over dolomite or aragonite over calcite (*5*). The absence of hydromagnesite moonmilk suggests that the hunite and the dolomite are not alteration products of hydromagnesite; however, the dolomite may have been altered from the huntite, as suggested by Moore (*4*).

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Suspensions: Fluids with Fading Memories

Abstract. *A sheared liquid suspension whose flow is reversed remembers with various degrees of perfection all earlier configurations of the particles. The memory effects, studied primarily because of their importance in suspension rheology, may be of wider significance.*

When a suspension of particles in a liquid undergoes a simple shear, each particle translates and rotates and interacts with others. Under proper conditions (*1*), the translational and rotational movements are retraced exactly when the direction of the motion of the fluid is reversed so that every preexisting configuration of the particle assembly is restored: the suspension thus possesses perfect memory (*2*). Changing the conditions (*3*) reduces the reversibility and impairs the memory by measurable amounts. We report the phenomena because of their importance in suspension rheology (*4*) and their potential use as models of information storage, memory, and time reversal (*5*) systems which are amenable to experimental and computational manipulation (*6*).

In our experiments we have used particles large enough to photograph, generally with a cine camera attached to a microscope, so that we can measure as many as three rotational and three translational coordinates of each of a number of particles at various times. Thus, if we take n pictures of N_0 particles, we can describe all particle configurations by $6nN_0$ coordinates, a number which can easily be made sufficiently large to have statistical significance.

As an example, we consider a dilute suspension (up to 100 particles per milliliter) of cylindrical rods, microtomed to a length of 870 μm from metallized nylon monofilaments 175 μm in diameter, suspended in an oil of the same density, and placed in the annulus between two vertical concen-