petence. Turbidity currents account for the sands and gravels which underlie the perfectly flat, strongly reflecting abyssal plains, for gravel and sand in submarine canyons, and for finer sediments in natural levees and abyssal cones, but they fail to account for the uniform shape and stratification of the enormous accumulation of continental rise lutite. Massive transport of continental rise sediment parallel to the contours for at least 1500 km is demonstrated by the construction of the Blake-Bahama Outer Ridge. This illustrates the powerful smoothing potential of deep geostrophic contour currents in the shaping of the continental rise.

The thickest sediments in the ocean are found beneath or very near the axes of deep geostrophic contour currents, and these deposits become thinner with increasing distance from the current axes. That this pattern holds for all beds from the latest postglacial to the underlying basement is demonstrated by cores, echograms, deeper-penetrating reflection profiles, and deep refraction studies. Thus the characteristic downslope thinning wedges of sediment which, stacked one upon another, comprise the continental rise appear to gain their shape through controlled deposition by deep geostrophic contour currents.

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19. This is Lamont Geological Observatory Contribution No. 900. Duke University's R.V. *Eastward* and the Bell System's C.S. *Long Lines* were made available for this study. We acknowledge the assistance of R. J. Menzies, Duke University oceanographic program and C. C. Duncan, American Telephone and Telegraph Company. R. Craig, J. Connally, J. Cason, R. Thomas, and P. Buckel greatly aided the work. J. Damuth, B. Glass, E. Haff, A. Lowrie, R. and Judith Niggl, D. Ninkovich, Marie Tharp, and D. Wands assisted on R.V. *Eastward*; C. C. McGruder, A. Lowrie, and C. Ellis assisted on C.S. *Long Lines*. J. B. Hersey and R. M. Pratt made available for study their extensive collection of bottom photographs. Discussions with C. L. Drake, J. E. Nafe, J. L. Worzel, M. Ewing, G. Wüst, J. Groot, D. B. Ericson, T. Ichiye, and E. D. Schneider have been quite helpful. Supported by the Office of Naval Research and the National Science Foundation (G17669).

17 January 1966

Piezoelectricity in Secondary Explosives

Abstract. *A theory for the formation of "hot spots" necessary for the initiation of an explosion is discussed in light of experimental evidence that most solid explosives are highly piezoelectric.*

It is generally accepted that the initiation of explosion in all explosives, both primary and secondary, is connected with the formation of "hot spots" (*1*) within those materials. However, up to now there has been no really acceptable explanation regarding the formation of hot spots, and hence the question of explosive sensitivity is still unresolved. Because of this situation we have initiated a program aimed at elucidating some of the electrical properties of secondary explosives in the belief that these properties may be important in explosion initiation.

The fundamental, relatively unknown, properties of the secondary explosive cyclotetramethylene tetranitramine (HMX) are now reported. Large single crystals of β-HMX were used in our experiments. HMX powder free of trinitrotriazacyclohexane (RDX) was obtained by extracting 98-percent-pure HMX (*2*) with 1,2-dichloroethane for 24 hours. The product was then dried in a vacuum and dissolved in boiling acetone; the acetone solution was cooled at the rate of 3°C per day, a rate that usually produced about ten large single crystals of β-HMX. After filtration the crystals were dried in air.

The single crystals of HMX exhibited piezoelectricity since a d-c voltage is generated when a load is applied to the crystal. This phenomenon was studied as a function of the applied load. A typical example for δ-HMX is shown

in Fig. 1. It is very apparent that the generated field depends linearly on the applied load. Piezoelectricity was difficult to measure for the β-polymorph since it is very soft and usually crumbled under the applied loads. The δ-polymorph crystals were obtained by heating the β-polymorph to about 250°C and then cooling to room temperature. The data shows that very large electric fields are generated within these crystals even with the application of a relatively small load; for example a field of 10 volts per centimeter was generated by a load of 400 g on a crystal whose area was 0.42 cm^2.

Since HMX is a secondary explosive it cannot be detonated without either a primary detonation of the explosive or one of a mechanical nature. If the piezoelectric voltage still depends linearly on pressure, in an average primary detonation of 500 kbar the generated field due to a detonation can be of the order of 10^7 volts/cm. This electric field is high enough to cause electrical breakdown (electron avalanche) within the crystal and hence to generate localized "hot spots" that finally result in explosion. By inspection of the crystal structures of RDX, TNT, PETN, NH_4NO_3, NH_4ClO_4 one finds that all these secondary explosives have crystal structures which should exhibit piezoelectricity. This same phenomenon could explain some of the strange properties of the azides. It is well known that lead azide can explode while being grown in crystal form from solution. It is well established that crystals can be extremely strained while growing. Thus one could envisage that the strains cause a piezoelectric voltage to be generated with subsequent explosion.

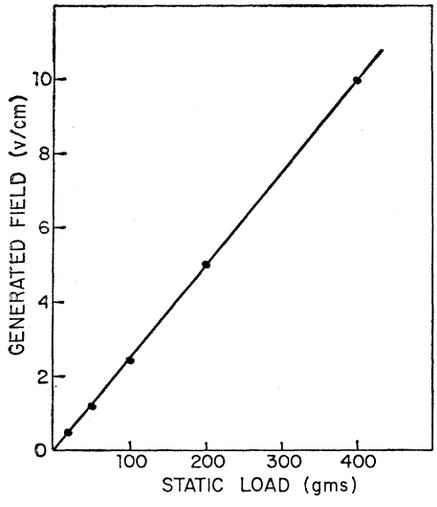

Fig. 1. Generated piezoelectric field as a function of applied load on a single crystal of δ-HMX at room temperature.

Thus some of the hot spots necessary for explosion of solid explosives might be produced by electrical breakdown of the crystal owing to a generated piezoelectric field.

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1 March 1966

Isopycnic Centrifugation for the Isolation of DNA Strands Coding for Ribosomal RNA

Abstract. *Denatured DNA preparations from* Escherichia coli *were centrifuged to equilibrium in cesium chloride solutions. Hybridizing experiments with radioactively labeled ribosomal RNA showed that the DNA strands complementary to ribosomal RNA were distributed on the heavy side of the DNA band. By fractionating this band the DNA strands coding for ribosomal RNA may be enriched 5- to 20-fold.*

When a DNA preparation is centrifuged to equilibrium in a cesium chloride solution of appropriate density, the CsCl is redistributed in the liquid column and forms a density gradient in which the macromolecules are concentrated in a zone, or band, at a height in the gradient corresponding to their buoyant density (*1*). Native DNA exhibits a buoyant density which is in general linearly related to the mole percentage of guanine and cytosine in the molecule (*2*). When DNA is denatured the separated strands of the double helix usually have a buoyant density higher than that of the native molecules by approximately 0.015 g/ml.

Most viruses contain single molecules of DNA. Such DNA preparations show narrow bands in CsCl gradients, the sharpness reflecting the lack of molecular heterogeneity. In the cases of a few viruses, such as phage α (*3*, *4*), it has been found that on denaturation each of the complementary strands of DNA gives rise to a separate band in CsCl instead of one being super-imposed on another. It has been suggested that pyrimidine-rich strands are denser than purine-rich strands and that in these bacteriophage DNA's the composition of each of the paired strands is so disparate as to endow the strands with differing densities (*5*), whereas in most DNA preparations, presumably fortuitously, the ratio of purine to pyridine of all strands is similar and the molecules in the denatured preparation have not been resolved up to the present.

Analyses of these separated strands in the case of bacteriophage α show that the ratios of purine to pyrimidine bases in the strands are 0.78 and 1.18 (*4*). The difference between these ratios is less than that which must exist between the strand of DNA coding for ribosomal RNA and its complementary DNA strand [purine:pyrimidine = 0.773 and 1.227, and 0.725 and 1.275, for 16*S* and 23*S* RNA from *E. coli* (*6*)]. Experiments were therefore set up to test the possibility that the strands of DNA coding for the ribosomal RNA might be found situated eccentrically from the bulk of the denatured bacterial DNA after equilibrium centrifugation in a CsCl gradient. In this manner a preparation of DNA enriched in molecules coding for the ribosomal RNA might be obtained.

Preparations of H^3-labeled DNA were made from *Escherichia coli* B3 grown in a tris-glucose-casamino acid medium supplemented with H^3-thymine. Cells (5×10^8 per milliliter) were centrifuged and resuspended in 0.01*M* acetate buffer, *p*H 5.4, and lyzed by addition of sodium dodecyl sulfate (SDS) solution (to a final concentration of 2.0 percent SDS) together with washed bentonite (*7*) (to 0.5 mg/ml). An equal volume of neutral redistilled phenol was added to the mixture of bacteria and SDS, and after vigorous shaking the two phases were separated by centrifugation. The upper phase was removed and shaken a second time with fresh phenol; after centrifugation the nucleic acids were precipitated from the upper phase by addition of NaCl (final concentration 0.1 mole/liter) followed by two volumes of ethanol. The nucleic acids, redissolved in 0.01*M* EDTA ethylenediaminetetraacetate, *p*H 7.5, were treated with