PHYSICS

Spring-Built Molecule Models Simulate Vibration of Atoms

Motion of Actual Molecules As Measured by Spectra Duplicated in Models at General Motors Laboratories

VIBRATIONS of steel balls and spiral springs now give science exact information on the motions occurring in actual molecules far too small to be seen with the human eye..

Dr. C. F. Kettering, general director of General Motors Research Laboratories, Dr. D. H. Andrews, now at the Johns Hopkins University, and L. W. Shutts, of the General Motors Laboratories, have agreeably surprised physicists all over the world by constructing mechanical models in which the various kinds of atomic vibrations occurring in, for instance, a molecule of benzene can be visually observed. These models reproduce the light radiations or spectra from liquid benzene.

The models are constructed of steel balls connected by spiral springs. The balls have the same relative weights as the carbon, hydrogen or oxygen atoms they represent. The web of balls and springs is freely suspended and connected to a vibrating rod whose speed can be varied by an electric motor. At definite frequencies of vibration, which are recorded on a counter, the model takes up a characteristic motion.

Those rates at which the model resonates are found to agree remarkably with the frequencies observed in light scattered by the substance.

Theory Borne Out

The investigators postulated that the forces connecting the atoms in a molecule are the same as if the atoms are connected by spiral springs. These forces were imagined to lie in the chemical bonds which elementary students of chemistry represent when they write chemical formulae.

A spring can either stretch or bend. Specific heat measurements previously made by Dr. Andrews showed that probably the same is true of the chemical bond. Equally surprising was the further result that the elasticity or springiness of all bonds is the same.

The first model made was of benzene, a molecule consisting of six atoms of carbon and six of hydrogen, and was made rather diffidently. Definite numerical results were not expected. In constructing the model the springs had to be strong enough so that the stretching and bending forces on the balls would be large in comparison with gravitational forces. Also the balls and springs had to be so related that the vibrations would be of a speed that could be observed by the flickering light of a stroboscope. The models were suspended by thin rubber bands.

A stroboscope permits the observation of more rapid vibrations than can be seen with the naked eye if the frequency of the flicker is brought close to the frequency of the oscillations.

Chart of Vibration

A chart of the rates of vibrations was made. It was immediately recognized that the arrangement of lines was practically identical with those in the so-called Raman spectrum of benzene, which is also due to vibrations within the molecule. A simple calculation then enabled the investigators to convert the model's rates of vibrations into Raman frequencies.

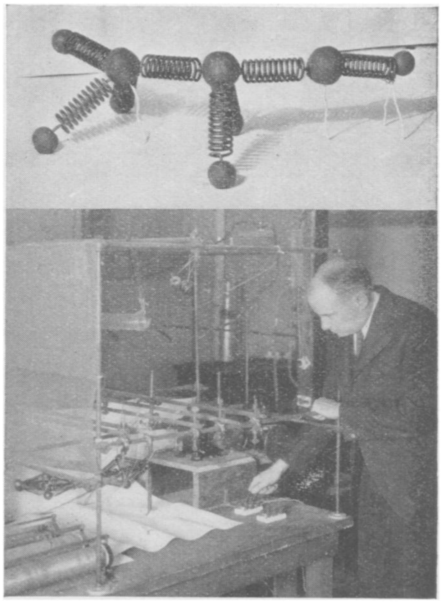
The Raman spectrum is obtained by observing through a prism spectroscope the light scattered by a liquid or solid from a beam of light. Mercury arc light containing only single wavelengths was used. The original lines of the mercury spectrum are accompanied in the scattered radiation by subsidiary frequencies which are found, on examination, to be due to vibrations of parts within the molecule. These are also shown by the heat radiated by the substance. The 1930 Nobel prize winner in physics, Sir Chandrasekhara Venkata Raman, of the University of Calcutta, discovered the effect that bears his name.

The benzene model vibrated in several ways. The two halves sometimes vibrated like a bird flapping its wings, or three atoms went up while the alternate three went down, or all six atoms went in and out from the center.

Models of toluene, carbon tetrachloride, chloroform, ethane, ethylene, acetylene, ethyl and methyl alcohol were also made and found to give good agreement with their Raman radiations.

By watching the motion of the parts of these models, the chemist gets a real moving picture of the way the atoms are behaving in a chemical compound and this enables him to understand many obscure points of chemical behavior.

Science News Letter, January 17, 1931



WATCHING ATOMS VIBRATE

Dr. Andrews, with the aid of the stroboscope, is observing motion much more rapid than can be seen with the unaided eye. A close-up of a model of the alcohol molecule is shown above.

ENGINEERING

An American Romance In Steel and Steam

See Front Cover

THINGS mechanical offer the photographer an unlimited field for the exercise of his talents; and the locomotive, romantic and symbolical as it can be made, is especially attractive to him.

On the front cover of this week's SCIENCE NEWS LETTER, Photographer Rittase of Philadelphia has chosen the Boardwalk Flyer of the Reading Railroad as the subject of a fascinating study. The Boardwalk Flyer runs from Camden to Atlantic City and is considered one of the world's fastest trains.

This fact makes us look at the picture a second time. But the photographer might have done equally well with any other locomotive in the world, so universal is interest in the railroad.

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