CHEMISTRY-PHYSICS

Chemical Music and Its Meaning

The Transposition of Atom Vibrations Into Harmony Suggests A Possible Link Between Music and Science

By D. LINDSAY WATSON

HAVE you ever tried gasoline on your piano? Or alcohol? Or water?

This is not a household hint but a contribution to science, for Dr. Donald H. Andrews of Johns Hopkins University has transposed the vibrations of chemical atoms, written them as music and played them as modernistic musical chords and runs.

Try these chemical theme songs on your piano. The melody of the gasoline that runs your auto is frankly reminiscent of jazz—it reminds one of the Rhapsody in Blue. Water, played by Dr. Andrews, is a pleasing ripple on the notes of the piano, like a waterfall, clear and sparkling. Alcohol gives a rich, resonant chord, dreamy and seductive.

Every chemical substance sings a song of its own which can be written and played as music. By this fact a new source of thematic material is opened up to the composer. By reversing the process the skeptical chemist may find that favorite melodies or chords can be translated into chemical formulae.

The analysis of familiar music, in the light of Dr. Andrews' idea, should give interesting results. It may be that the love songs of a Mozart opera are the transposed spectra of sugar, and that the agonized discords of Strauss merely depict the chemistry of a stomachache. The passion of a Wagner scene may turn out to be a powerful drug.

One of the most important fields of scientific research today is the probing of the chemical constitution of matter. In this sector of science Dr. Andrews has been working. He has been studying the way in which substances are put together, how the separate atoms of their molecules vibrate when they give off light and other radiations.

Every little atom has vibrations all its own. The rainbow spanning the summer sky gives scientific evidence of the vibrations of the atoms. Every color of light has its own period of vibration. The many-hued bands in the rainbow, which is a natural spectrum, each originate in matter of certain vibration rates.

Artificial rainbows are produced when light passes through a triangular piece of glass like the ornaments on old-fashioned chandeliers. Closely inspected, these spectra show lines running across them. Physicists have given a lot of attention to those lines for they give a means of telling what sort of vibrations are going on in the light and in the substance they come from. They can be photographed and thus recorded.

A spectrum photograph is a sort of finger-print of the light-producing atom or molecule. Each line or color in the spectrum corresponds to a definite rate of vibration in the substance. Different colored lights differ only in frequency or number of vibrations. By measuring the distance apart of the various lines the scientist can tell exactly what contortions the parts of the light-emitting molecule are undergoing.

Several methods of cross-questioning the molecule are employed. Dr. Andrews has been especially interested in the kind of spectrum that recently won the Nobel prize for its discoverer, Sir Chandrasekhara V. Raman. Raman used the idea that a substance may reveal its secrets more easily under the influence of light not its own. This method has the advantage of telling about the vibrations of whole atoms which form part of the molecule.

DR. DONALD H. ANDREWS

He has transposed the vibrations of chemical atoms, written them as music and played them as modern musical chords and runs.

Lines of Spectrum Shift

The Raman spectrum of alcohol, for instance, is the rainbow scattered from the substance when strong light from a mercury arc or other lamp plays on it. The lines of the mercury spectrum are found to have shifted because of the action of the alcohol molecules on the mercury light. The amount of the shift gives a measure of the number of vibrations made each second by some part of the molecule.

Models were constructed at the Johns Hopkins Laboratory by Dr. Andrews and others to help in explaining these vibrations. *(SNL—Jan. 17, '31.)* The molecule models were made of steel balls and springs. Dr. Andrews played with these quivering models a while and found that by transposing the Raman "shift"-vibrations, the various natural vibrations of the model could be obtained. The Raman spectrum is the physicist's musical score of the atomic symphony.

The success of this work gave Dr. Andrews the idea of transposing the spectra into sound vibrations.

Sound, like light, is also a vibration but in a different physical medium, the air. The vibrations of light travel in the ether, whose real nature is still a mystery to physicists.

There is another important difference between sound and light. The vibrations of the parts of a molecule causing light waves are about a million, million, million times more in each second than for ordinary sound vibrations. Sound vibrations begin in the vocal cords or instrument and travel out as waves. Noise is irregular vibration. Music is rhythmically recurring vibration, anywhere from 20 to 15,000 cycles per second. Twenty would be a scarcely audible rumble, 15,000 the shrillest squeak.

The transposition of the Raman spectrum on to a musical scale offers no real difficulty. The answer of most scientists to the proposal to do this would be "what of it?" or "why bother?" So they never tried it. And thus it was left to Dr. Andrews to wonder if perhaps hidden harmonies are to be found in the spectra. For the essence of harmony is in the relations between the vibrations of the several notes, not in the actual number of vibrations of a single tone.

30 Billion Times Faster

By a simple trick, it is possible to get a very good idea of what atoms would sound like if we could tune our ears to them. Dr. Andrews noticed that the Raman frequencies when divided by a constant number, 30,000,000,000 (which is the velocity of light) gave rates of vibration corresponding to notes at the top of the piano keyboard. These are well known to physicists as the wave-numbers of the lines. By reducing these musical notes two octaves the whole spectrum can be brought to the middle of the piano.

Benzene, water, alcohol, gasoline and wood alcohol are among the first substances tried. Decidedly characteristic and sometimes pleasing effects were obtained. Wood alcohol, in sharp contrast to the grain alcohol, had a vicious sound curiously in keeping with its drastic physiological effects.

A significant link between chemistry and music has thus been forged. To every chemical substance there corresponds a Raman spectrum and, therefore, a possible combination of musical notes. The notes for a given substance can be written or played as a chord, that is simultaneously, or as a melody consecutively.

Composers who seem to be hard put to it to unearth bizarre material may be expected to welcome this unexpected assistance from science. Without making any assumption as to the significance of a given chord it is perfectly possible for them now to go in search of inspiration to the laboratories of physical optics where the Raman spectra are being measured.

The entrance of the snappy "vamp," for instance, would be heralded by the chord of iron oxide, Fe_2O_3 (or rouge) played by the oboe. A cold in the head would be symbolized by the aspirin motif, the heroine by geranial, a constituent of rose perfume, a mosquito by citronella. The chords of alcohol and gasoline would no doubt find wide use in a modern composition.

The body is a harp of a thousand strings. Our liking for a melody may be because we too can vibrate to it like the molecule from which it came.

The chemist in search of new dyestuffs will now have a new source of information. He will simply search for a particularly iridescent passage in Debussy. After a calculation he can write down the formula of a brilliant colored substance and proceed to make it in his laboratory.

All this may seem far removed from "serious science." Suppose you look back again for a moment. Why do some combinations of tones sound pleasant, others harsh and discordant? This question has been a puzzle to physicists and philosophers throughout history.

Pythagoras, the ancient Greek philosopher, was fairly near the answer when he sought for the causes of harmony in the occult miraculous power of numbers—especially simple numbers.

"In listening to music," said Leibnitz, celebrated German mathematician, "the mind is counting without knowing it."

Think that over. Doesn't it take us very near to a scientific meaning of these chemical melodies? And very near to nonsense too?

A note of 400 vibrations each second played along with one of 200 per second sounds very pleasing. The first would, in fact, be just an octave above the second. On the other hand, notes of 210 and 200 sound very discordant together; but 300 with 200 is harmonious.

In this sense certainly, Leibnitz is mysteriously right.

If then, on playing Dr. Andrews' chemical chords scientists find that pleasing combinations of tones are more frequent they would be justified in looking back to the Raman spectra with the expectation of finding simple numerical relationships between the frequencies of a given molecule.

Dr. Andrews, however, makes no claim that his work has shown this. Too much emphasis must not be placed, for instance, on the fact that the chords of benzene and alcohol have some well-known harmonic groupings among their notes. It is, he admits, possible that simple underlying relationships do, in some cases, connect the notes of a chemical harmony, but the experimental results do not as yet permit him to draw such a far-reaching conclusion.

It remains an attractive possibility with perhaps a little support from theory. It would indeed be reassuring to find that common substances of our acquaintanceship gave, on the whole, a good account of themselves constantly emitting a pleasing combination of radiations.

The important thing is that a new method has been brought into play in chemistry, throwing a different kind of light on the experimental facts. We can now perceive the fundamental relations by another sense—a fact of immense significance for the development of science.

Truth and Emotion

This is, however, dangerous ground we are on. Scientists have always believed that they cannot reach the truth unless they can keep their emotions from interfering with their work. Yet music appeals almost entirely to emotion.

How can science learn anything from such a treacherous ally?

You have heard of Einstein's violin. The greatest scientific figure of our age performs on the violin with the skill and feeling of a professional. He has given successful recitals. You may object that Einstein's love of music does not enter into his science. Perhaps it does in the following sense.

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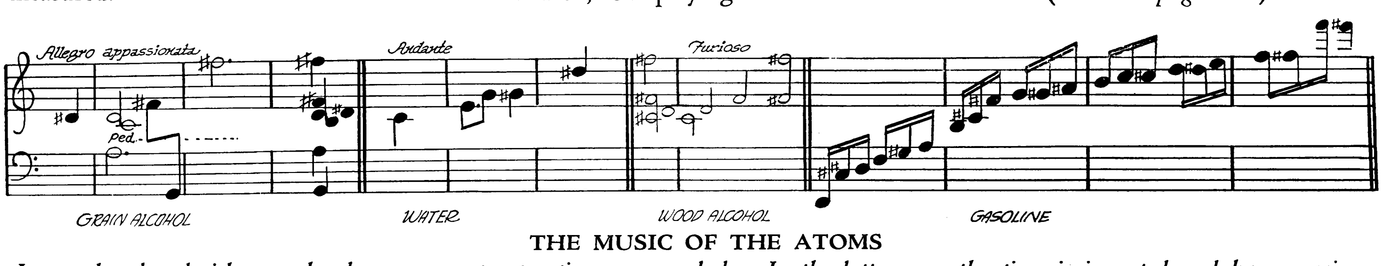

THE MUSIC OF THE ATOMS

It may be played either as chords, or one note at a time, as a melody. In the latter case the time is invented and has no scientific meaning. Only the pitch is derived from the Raman spectra. A composition using the chord of water has been made by Abram Moses, formerly of the Peabody Institute of Music, Baltimore.

BOTANY

Nature Ramblings

By FRANK THONE

"By Their Fruits"

"WHEREFORE by their fruits ye shall know them."

Oak trees are good trees, and therefore acorns are by Scriptural rule good fruits. There is plenty of natural testimony to this end, borne by animals so diverse as squirrels and swine. Even man is an acorn-eater in some parts of the world; before the padres brought grain to California the Indians there pounded the fruits of the oak to the meal which was their staff of life.

But acorns are not just acorns. Every oak differs from every other oak, and each oak species bears a quite distinctive acorn. In fact, the acorns are often more distinctive than the trees that bear them. Some nearly related oaks look so much alike in trunk and branch and leaf that even a botanist or a forester will be stumped at first to tell them apart, but if he can find a few of their acorns lying about his difficulties are over.

Some specimens of black oak, for example, look rather like red oak trees. But they always bear black-oak acorns; whereon the cups are deeper, more conical and more shaggy-scaled than are the red-oak acorn cups. The cup of the red oak is really more like a saucer. It is shallow, flat, close-scaled, and it just grips the base of the acorn. Strongly contrasted with this is the acorn of the bur oak, which is frequently buried almost to the tip in the shaggy coat of its cup.

In shape also the acorns are distinguishable. The acorn of the bur oak is usually big and round and plump, that of the white oak and the red oak middle-sized and bluntly pointed, while the acorn of the black oak is slender, almost bullet-shaped.

Science News Letter, April 25, 1931

ARCHAEOLOGY

Prehistoric Remains to be Sought by Engineers

COOPERATION between scientists and engineers, road builders and other professional men conducting large-scale digging operations, in a search for remains of early man in America, has been arranged at a conference held in Chicago under the auspices of the National Research Council.

Because some of the most important of the old-world finds of ancient man were made in quarries, gravel pits and other utilitarian excavations, it was believed by the organizers of the program that a well worked out plan, enlisting the assistance of interested engineers and contractors, might be productive of equally important results on this continent.

Prof. Fay-Cooper Cole of the University of Chicago introduced the general subject of early man in America, and Dr. W. C. Alden of the U. S. Geological Survey discussed the spread and movements of the great ice sheets in the Middle West.

What the engineer or roadbuilder may do, to be of the greatest service to science, was suggested by Dr. M. M. Leighton, chief of the Illinois State Geological Survey. He said, in part:

"Engineers and operators in charge of all kinds of excavation work such as road building, sewer construction, dredging ditches, quarrying and clay, sand, and gravel industries, are in position to make valuable contributions to science with regard to the geological history of man in America, by preserving in situ suggestive evidences of human occupation, whether it be skeletal remains or the relics of his activities, until the scientific evidence of the geological position and age can be determined by a geologist and notifying the State Geologist of that particular State regarding the potential discovery; such leads should be followed by prompt examination on the part of the State Geologist or some capable geologist whom he may designate.

"The whole procedure could be encouraged by the establishment of a geological minute-man service similar to the archeological minute-man supported by Science Service, whereby moderate sums covering the cost of the field examination may become instantly available. . ."

Science News Letter, April 25, 1931

Chemical Music

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There has always been a close bond between mathematics and music in addition to that found in the study of harmony. It is the commonest thing for a mathematician to be a great lover of music. Mathematics is the most abstract of the sciences, music the most abstract of the arts.

Perhaps the mind uses similar abilities in these two activities. Despite the apparent gap betwen art and science they have much in common.

You have probably thought of the scientist as rather an insensitive person intent on achieving results of use to humanity and altogether lacking in playfulness or feeling for beauty.

Great world scientists have not agreed with this view. There is indeed much of the scientist's work which must be done in a chilly, unemotional atmosphere but unless a quality is present from time to time, similar to what we find in creative artists, great science does not arise or grow.

Science News Letter, April 25, 1931

A Dutch air mail line covers 10,000 miles between Amsterdam and Batavia.