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Epistemes of Modern Acoustics

Sound & Science: Digital Histories

Smith, Hermann. “On the Process of Tone-Making in Organ-Pipes.“ Nature 10, no. 259 (1874): 481-482.

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MAX PLANCK INSTITUTE
FOR THE HISTORY OF SCIENCE

Huyghens, that the following is sent you for publication in the old conservated form :—

$A^8C^3DE^{12}F^4GII^6I^6L^3M^3N^5O^6P$
$R^4S^5T^{14}U^6V^2WXY^2$ WEST

"Manufactured Articles"

THERE are precedents to justify a hope that it would be no excursion beyond the province of NATURE, if somebody who knows that molecules possess the essential character of a manufactured article were kindly to explain how he knows a manufactured article when he sees it, in his mind's eye or elsewhere.

The answer used to be "contrivance, design; an end, a purpose; means for the end, adaptation to the purpose." This, it was said, we find in a watch; "we perceive that its several parts are framed and put together for a purpose." The same thing, it was further said, we find still more in the works of nature, "and that in a degree which exceeds all computation." And why so much more? Because "the contrivances of nature surpass the contrivances of art, in the complexity, subtlety, and curiosity of the mechanism; and still more, if possible, do they go beyond them in number and variety." This was the old answer: the new one is contained in such phrases as these: "exact equality," "exact unison," "exactly the same magnitude," "constants not approximately but absolutely identical."

Here it is hard not to stop and ask what can possibly prove that these things are absolutely so: or what can possibly contribute the smallest probability to a hypothesis that anything is absolutely anything, I do not say among the laws of nature, but among its collocations. Very likely it might be proved that the mean-square variation in the value of one of the above-mentioned constants is a prodigiously smaller fraction of its mean value than any other fraction which the molecular theory has occasion to take account of; and anyhow the fact remains that a molecule of bismuth, for instance, differs from a molecule of lead immensely more than two molecules of either can differ from one another. Perhaps this will do as well for the argument; if so, there is no excuse for the absolute; and whether or no, the argument will be the better for explanation, or perhaps it will be the worse for the argument.

However this may be, the difference between the old answer and the new one is rather instructive. An eager disputant might say the new one was contradictory of the old one; but it is safer to say that the new is at best independent of the old. Clearly a watch is about the last thing which would be cited to illustrate the new sort of manufactured article. The examples which our authors do by preference cite are coins, weights, and measures; and certainly it would be difficult to name manufactured articles which should better exemplify uniformity for the sake of uniformity. And for a very good reason (that is the worst of it); because the purposes of coins, weights, and measures are defeated, they who handle them deceived, and (as our authors are careful to say) they who manufacture them deceivers, so far as the things are not uniform. So the inference from such things only comes to this, that uniformity is a character of manufactured articles when uniformity is part of the purpose of manufacture. Is then the new argument, after all, a special case of the old one? Not so: for when men produce as a novelty a special case of an old argument, this must be because it is an especially strong case of the same; but we have seen that the old argument owes much of its virtue to complexity and variety; therefore, our modern manufactured articles, which are above all things simple and uniform, will only furnish a special case of the old argument by furnishing an especially weak one. Design, in short, has nothing to do with the new argument, and we must look for analogies among manufactured articles which are uniform, not because uniformity adapts them to their purpose, but simply because they *are* manufactured articles.

The nearest approach I can think of is to be found on a scale almost molecular, for number and sometimes for magnitude, in a London wilderness of similar and similarly situated houses. It is oppressive to walk past these boxes so nearly identical in form, and to think of the infinite variety of their contents; to think how different they would have been, and how much fitter for their purposes, if their inhabitants could have secreted them as a snail secretes his shell. And why does it make all the difference that they have been manufactured? Why did not the manufacturer vary them according to the interests connected with them? Of course because he did not care about those interests; because he could not foresee them; and because it would not answer to try and provide for them. And now we understand the sort of manufacturer the new argument reveals: a manufacturer who does not care what becomes of his articles the moment he gets them off his hands by his formulas beginning to be interpretable; a manufacturer who cannot solve his own equations except in a grossly approximative fashion; a manufacturer who could not give his constants the proper values if he knew what values to give them.

Uniformity, in short, is not as such the sign of a manufactured article, except as it may be the sign of an imperfect manufacturer. I do not suppose this is what the new argument is meant to mean: but this, I submit, is what it does mean. Perhaps, however, some competent supporter of it will kindly explain it a little. C. J. MONRO

Yorkshire College of Science

WILL you permit a few words upon your allusion to this College in a leading article of the 8th inst.?

If its promoters have confined their present efforts to the establishment of a Faculty of Science, one cause has been that the amount of their funds compelled a selection instead of a comprehension of subjects. With a capital of 26,000*l.* they could not venture to cover so large a field as Owens College commenced upon with an invested endowment of four times the amount. But already, before our doors are opened, we have cheering signs that in providing a function to which endowments may be entrusted, the College will accrete to itself aid from widely-divergent quarters. The Royal assent has been given to an amended scheme of the Endowed Schools Commissioners for the Akroyd Charity, by which an important annual residue is allotted to the College, with representation upon the Trust. By the liberality of the Cloth-workers' Company, the sum of 500*l.* per annum is set apart for three years for a Professor of Textile Industries and for Scholarships. Is it unreasonable to hope that new professorships will be established by the generosity of private individuals? The existence here of a flourishing School of Medicine is favourable to your views of massing the Faculties, and already a first link of union is being forged between the two bodies in relation to the classes in Chemistry.

Do not suppose that the College adopts *Pannus mihi panis* as its motto. A thoroughly practical community must run a risk of magnifying the *practice* of science rather than its *theory*, but if the selection of professors has been fortunate, there is no doubt that students will be taught practice through theory. Your forcible remarks will doubtless strengthen the hands of certain liberal donors to the College, who have offered increased sums when an Arts Faculty can be established.

Leeds, Oct. 12 R. REYNOLDS

On the Process of Tone-making in Organ-pipes

THE natural order of harmonic progression in an open organ-pipe is well known. That there is from the same pipe an inverse order of harmonics equally natural is not equally well known. There is no intimation that I am aware of, in any treatise on sound, of this fact having been observed, and the absence of recognition is no doubt attributable to a general disregard of the study of the comparative acoustics of musical instruments. My investigations into the process of tone-making in organ-pipes and other instruments have clearly shown me that there is *an order of transitive* harmonics distinct from the *order of concomitant* harmonics or "over-tones." Why I call them "transitive" will be apparent in the argument. Certain it is that our mimaphonic power in organ-pipes and in other musical devices depends on the command we can ensure over these two orders distinctively, and also on their comparative influences on the tones produced. In this manifestation of an inversion of harmonic progression, the nature, and, without extravagance one may say, the individuality, of the aëroplastic reed is most fully pronounced. Experimental proof is easily obtained, and, whilst bringing into prominence the peculiar display, will at the same time furnish indubitable evidence of the formative power exercised by the air-reed in the process of tone-making.

By the term "tone-making" is to be understood the manner of origination not merely of a note of defined pitch emitted by a musical instrument, but also of all the constituent sounds which give colour or quality to the note, and enter into the effect perceived by the ear. The artist, according to his sagacity, seizes

on the faintest hints of nature, and with more or less consciousness of insight into law is able to control the process.

The modern theory of musical quality, or *timbre*, for which we are indebted primarily to Johannes Müller, and subsequently to Helmholtz, who by elaborate investigation has made the subject specially his own, takes account only of the varying intensities of the harmonics present in the compound tone, classed in two series, the "open" and the "stopped," or otherwise the "even" and "uneven," in regular progression. To the system of associated sounds in harmony the present inquiry has no reference; my purpose is to press the claim for recognition of another series in addition to these, to show that quality, and especially mimaphonic quality, in sounds, in whatever degree attributable to harmonics combined with the fundamental, is no less dependent for its character on the "order" in which harmonics come on or develop themselves in the growth of the tone. In plants there is a direct order of appearance—leaves, then flowers; a reversed order is as natural, and flowers come before leaves.

If an "open diapason" pipe of small scale is taken, and some slight variation made in the voicing, the pipe may be converted into a "flute harmonique," and it will give a note an octave higher than before; that is to say, the fundamental is abolished, and the octave or first harmonic reigns in its stead. The pipe will probably be now "unsteady," frequently attempting to reinstate the fundamental. This tendency we may counteract by drilling a small pin-hole at the side of the pipe, and the trifling amount of external air thereby admitted will destroy the tendency, by preventing the perfect formation of the node required by the fundamental. The perforation should be made at the true point of localisation of the node, which (as explained in a former letter in NATURE, vol. ix., p. 301) is at about $\frac{3}{7}$ of the whole length of pipe reckoned from the level of the mouth. If we next enlarge the hole at the foot of the pipe, thus allowing greater force to the wind-current, and if we have properly manipulated the pipe, we shall on the trial of its sound hear the twelfth coming on as the forerunner of the octave, most distinctly and with a perceptible interval between the appearance of the twelfth and octave. The effect is more certain if the mouth is cut to a height less than that marked by scale, which would be $\frac{1}{3}$ of the width of mouth; and if, further, the pipe is slightly coned—a provision favouring the harmonic. By other changes of treatment, the fifteenth or double octave may be brought out as the introductory harmonic, and the twelfth following, and if we will we may restore the original ground-tone. The "flute harmonique" in this style is to be chosen for this experiment, not as representative of quality, but that in this overstrained condition it clearly defines the entrance of each harmonic, the order of succession, and the interval between each. In other varieties of pipe the "quality" is characterised by these harmonics, and in this order, but so blended as it were in a "portamento" glide that even critical ears fail to detect the elements combined into the effect. It is, so to speak, "an excess" of nature, which is often necessary to open our eyes to the perception of her commonest realities.

A diapason pipe is never so strong and brilliant in character as when it is just verging on the transmutation of fundamental to octave; for good vigorous quality, therefore, it is restrained only to just within the limit; nevertheless the presence of the octave-harmonic as the precursor of the fundamental should always be felt with its jubilant energy, then afterwards, the fundamental taking full possession of the pipe, producing its own octave-harmonic with almost equal exuberance of power. The precursory harmonic is of the transitive order. We have to recognise two distinct series of open harmonics—the direct order, *over-tones of the pipe*, which are derivatives of the fundamental, and the inverse order, the tones of which may be called *stem-tones of the reed*, for they are thrown off by the reed in swift succession, and declare the non-isochronous nature of the air-reed's motion. There is nothing erratic about these stemnal harmonics or the order of their appearance; they are due to the untamed vigour of the reed, and have this distinguishing law—they are transitive, each one dies in giving birth to the next, whereas the over-tones of the pipe coexist with the fundamental, and are the direct consequence of the excess of excitation in the air-column of the pipe (see more at length in NATURE, vol. viii., p. 383), providing a safety-valve for the permanence of pitch in the ground-tone, by employing the surplus energy acquired from the reed's vivacity in new forms of growth.

Whenever from an organ-pipe we hear harmonics together with the fundamental, then the air-reed is vibrating to its fullest amplitude, for it is the superabundant vitality of the air-column that sustains the coexistent ones; but when we hear harmonics independent of the fundamental, then we may be sure that they are the expression of the higher activity of the reed itself, then working with lessened *amplitude* of motion, yet with greater *velocity* of vibration.

The genesis of these tones is due to the association of reed and pipe. Without the pipe the reed could not produce tone, would be barren as one sex. As the pipe is silent and requires some external impulses to bring it into life, so the air-reed needs something to act upon before it can vibrate or swerve from its course in minute degree; some inequality of environment is all it asks—some alliance with power distinct from its own. Take away the pipe, leave it only the mouth, and it will pull against that and begin to work according to its nature, and even in that rudimentary condition will elicit tone of definite pitch.

Many classes of organ-pipes give harmonics of the direct order without a trace of those of the inverse order; on the other hand, the several varieties of pipes which give the inverse order invariably yield the direct order subsequently with the ground tone; and why? It will be comprehended at once, if I have rendered my meaning clearly, that the initial harmonics proclaim the intense vigour of the reed, and that force, unabated in strength, although widened in scope, is transferred to the air-column of the pipes The difference of effects produced by the two orders constitute. that variety of quality which distinguishes string-tone from horn-tone, and a further modification chiefly in relative times of sequence asserts its peculiarity as reed-tone; yet, again, there are in both series departures from truth of pitch, in some qualities an over-flatness of one or more harmonics, and in some an over-sharpness. The blast of the trumpet combines both flat and sharp harmonics strongly. The *direct* order of harmonics may be likened to an ascending arpeggio coalescing into a chord—the *transitive* to a descending arpeggio, in some instances having intervals regularly defined, in others starting abruptly and with wayward intensity, and in other displays passing swiftly onward to the fulness of tone, imperceptibly blended as is the "portamento" glide of voice or string.

In all the "Geigens" and "Gambas" and similar organ-pipes mimaphonic of "stringy quality," the transitive harmonics are the true cause of their speciality. Numerous experiments prove this to the eye as well as to the ear. I shall be able to show that the "Gambas" are characterised also by an over-sharpness of these transitive harmonics, and this paper is a necessary introduction to my proposed examination of the mode in which the peculiar quality of tone is built up in this attractive class of pipes.

HERMANN SMITH

Can Land-Crabs Live under Water?

PERMIT me to inform Mr. J. C. Galton that the authority for my statement in the "Outlines of Physiology" is also derived from "some book or other;" and that this "turns out" to be the classical "Hist. Nat. des Crustacés" of Milne-Edwards, vol. ii. pp. 16, 18, with which perhaps your correspondent is unacquainted.

Milne-Edwards, in his turn, refers (p. 19) to those who have studied the land-crabs in the Antilles and on the South American coast, viz, Rochefort, Feuillée, Labat, and Brown. He elsewhere, also, treats the subject as a comparative anatomist and physiologist (Ann. des Sciences Nat.; Todd's "Cyclopædia").

Whether the land-crabs of the east differ in their habits from those of the west is of course open to inquiry; and also in what ways (either anatomically or physiologically) they differ; but the question is clearly not whether they can survive for a few hours under water, but whether practically they can live in that element or are at last asphyxiated in it.

10, Savile Row, Oct. 6 JOHN MARSHALL

Bright Meteors

AT 8.55 this evening a party of six observed a meteor in the constellation Aries, or below it, which emitted light sufficient to cast a bright gleam on the neighbouring trees. The body of the meteor shot rapidly along a course extending about 20°. It then seemed to explode suddenly, and its track was luminous for a short time. The granular *débris* of the meteor continued to pursue, with very much retarded velocity a path slightly deflected from its former course: it continued to do so for several degrees; and it was, I think, fully a minute after the explosion that several of us almost simultaneously exclaimed, "It is falling." It resembled the expiring light of one globe of a rocket charged