

PHYSICS AND AESTHETICS OF HINDUSTHANI MUSIC*

THE glory of Indian melodic art-music, both Hindusthani and Karnatic, lies in *Gamakas* (movements or graces), which form really their aesthetic feature. The nature of the graces and their physical counterpart in the matter of the slight rise and fall in pitch of notes which it engenders, are the real matters for scientific research in the melodic music of India. Conclusions on theoretical bases are not of much value, and the living art music should be studied by accurate and objective methods known to modern physics, to ascertain the scientific laws behind the art. The studies should be undertaken in collaboration with a physicist of sound knowledge and photographic curves should be obtained by suitable means of *Gamakas*, played true on a violin or vina, to the satisfaction of competent judges.

Considered from this point of view, the recent publication of Mr. Ranade appears rather disappointing. The author perhaps intends the book more for the benefit of the Western reader since no mention has been made in the text of the names of the six Hindusthani *Thats* (seven note ragas) (or the six model scales at page 97) nor of the names of the *svaras* (notes) entering into their composition in Hindusthani nomenclature, except to a small extent in the appendix. His references to flats, double flats, sharps and double sharps of D, E, F, A and B and the European signs affixed thereto (pp. 96 and 97) leave the reader bewildered as they are not used with their accepted meaning¹ though the vibrational values against basic 240 c.p.s., for C, are given.

Following Helmholtz's method of evaluation against the basic 1 of C (*Shadja*) the relative frequencies of the seven notes in the above 6 Ragas, arrived at by the author on theoretical considerations of consonance with the drone—a necessary accompaniment in Indian melodic art-music—are noted below:

1	<i>Bilawal</i>	1	9/8	5/4	4/3	3/2	27/16	15/8	2
2	<i>Khamai</i>	1	9/8	5/4	4/3	3/2	5/3	16/9	2
3	<i>Kafi</i>	1	9/8	6/5	4/3	3/2	27/16	9/5	2
4	<i>Asaveri</i>	I-	9/8	6/5	4/3	3/2	8/5	16/9	2
5	<i>Bhairavi</i>	1	16/15	5/4	4/3	3/2	8/5	15/8	2
6	<i>Bhairavi</i>	1	16/15	6/5	4/3	3/2	8/5	9/5	2

The omission as a model scale, of Yaman or Kalyani, one of the seven ancient Grecian scales, is surprising, since that Raga is sung largely both in the North and the South of India.

Items 1, 3, 5 and 6 have the two tetrachords in the relation of the fifth, while those of Items 2 and 4 have the relation of the fourth. The diatonic or major scale of European music, based on the sound principle of major chords from C (*Shadja*), F (*Suddha Madhyama*) and G (*Panchama*) has R.F.'s of 1, 9/8, 5/4, 4/3, 3/2, 5/3, 15/8 and 2: and the author's '*Bilawal*' scale is the same except that he substitutes for R.F. 5/3, R.F. 27/16. If R.F. 10/9 is substituted for R.F. 9/8, in the diatonic scale the principle of the relation of the fifth in the two tetrachords is satisfied and the result is that all the notes are musical notes including R.F. 10/9 adjudged to be so both by Helmholtz² and the Karnatic musician. In fact these are the frequency values at which the frets have been placed on the South Indian vina (with fixed frets) under the *Shadja* and *Panchama* strings.

Why should not the '*Kafi*' scale have R.F.'s 1, 10/9, 32/27, 4/3, 3/2, 5/3, 16/9 and 2, also satisfying the enunciated principle of the fifth in the two tetrachords? The author seems to have entirely ignored the possible existence in the first four scales of R.F. 10/9 in the region of D which is found in the early Grecian scales and in the Arabic scales.³

The above observations have been made to apprise the reader that the notes of scales are only the skeleton frame-work round which we have to clothe the melody and that the *raga* concept is entirely different from the *scale* concept. It does not really matter whether the notes in the scale are a comma sharper or flatter in the matter of the description of the scales. Hence it is that Venkatamakhi fixed his 72 possible scales in relation to the 12 fixed frets of the vina in the octave as $4 C_2 \times 4 C_2 \times 2$.

The author's statements at p. 132 that (1) the major sixth (R.F. 5/3) has an imperfect dissonance with the tonic in item 4 and (2) the minor sixth (R.F. 8/5) has a perfect dissonance with the tonic in item 5, are certainly incorrect. There is perfect consonance with the tonic in both cases.⁴

The author is rather hard on Karnatic music. A misstatement of fact has, however, to be pointed out. There are not merely 19 parent scales in which Karnatic melodies exist to-day. The great Thiagaraja (1767-1847 A.D.) has created melodic compositions in 45 parent scales (of the 72) and in 220 derivative ragas including those in the less known parent scales even now known and sung by the erudite.

In spite of these criticisms on the purely scientific side, the book will certainly be found

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to be of general interest. It contains a good account of the evolution of Indian Music from the Vedic times and also a bibliography of books for further study.

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1. Sir James Jeans, *Science and Music*, 1937, p. 166; Helmholtz, *Sensations of Tone*, Ellis' Translation, 1930, p. 17. 2. Helmholtz, *Ibid.*, p. 17. 3. *Ibid.*, pp. 284, 515, 516. 4. *Ibid.*, pp. 14, 332, (Items 29 and 28) and 333, note under table of roughness.

USE OF NITRIC ACID IN THE PRODUCTION OF PHOSPHATE FERTILIZERS

IN view of the difficulties that might arise in maintaining adequate supplies of sulphuric acid to the fertilizer industry, the Chemical Research Laboratory, Teddington, has been studying for the past two years the possibility of making phosphate fertilizers by methods which might effect a saving in the amount of sulphuric acid used. The most obvious alternative to sulphuric acid is nitric acid, for its production does not call for the use of imported raw materials, while the nitrogen value of the acid is recoverable in the form of a nitrogenous fertilizer, and this offsets to some extent the greater cost of the acid as compared

with sulphuric acid. Unfortunately, the action of nitric acid on phosphate rock leads to the production of fertilizer containing much calcium nitrate, which is a highly hygroscopic substance and causes the fertilizer to become damp and difficult to use. Consequently, the work at the Chemical Research Laboratory has largely been confined to the use of mixtures of nitric and sulphuric acids. Actually it has been found that products made in this way are more stable to atmospheric conditions than when nitric acid is used alone. The maximum amount of nitric acid which can be tolerated in order to give a product having a low absorption of moisture is when the mixture of acids contains about 2 mol. of nitric acid to one of sulphuric.

* Courtesy of *Nature*, May 19, 1951.

RESEARCH FELLOWSHIP AWARDS

AT a recent meeting of the Council of the National Institute of Sciences of India, the following awards of Research Fellowships, which are normally for two years, were made:—

NIS Senior Research Fellowships: Dr. A. M. Nagvi, Ph.D., "Solar Problems" at the University of Delhi; Dr. S. C. Shome, Ph.D. (Dacca & Cantab.), "Corrosion of Metals" at the National Metallurgical Laboratory, Jamshedpur; Dr. B. G. L. Swamy, D.Sc. (Mysore), "The Comparative Morphology and Relationships of Some of the Families of the Order Ranales," at the Madras University.

NIS Junior Research Fellowships: Mr. D. Basu, M.A., "The Waldian Approach to the Problems of Estimation," at the Indian Statistical Institute, Calcutta; Dr. M. Datta, D.Phil., "New Probabilistic Approach to the Basis of Statistical Physics," at the Calcutta University; Dr. A. M. Mehta, D.Phil. (Oxon.), "Investigation of Biles (from Slaughter-Houses in Bombay) with a View to Search for 11 and 12 Oxygenated Steroids Needed for Synthesis of Anti-Arthritic Compounds Related to Cortisone," at the Haff-

kine Institute, Bombay; Dr. A. K. Mukherjee, M.B., D.T.M., "Cultivation of *E. histolytica* in a Bacteria free Medium," at the Indian Institute for Medical Research, Calcutta; Dr. (Mrs.) T. S. Sarojini, Ph.D. (Madras), "Studies in Soil Fungi with Special Reference to Fusarioid Disease of *Cajanus*," at the Madras University; Mr. E. G. Silas, B.Sc. (Hon. Madras), "the Zoogeography of the Western Ghats as Evidenced by Distribution of Fishes," at the Madras University; Mr. T. B. Sinha, M.Sc. (Alld.), "the Morphology and taxonomy of Mites," at the Allahabad University.

ICI (India) Research Fellowships: Dr. B. K. Banerjee, D.Phil. (Cal.), "Physico-chemical Studies of Glass," at the Indian Association for the Cultivation of Science, Calcutta; Dr. A. Ganguli, Ph.D. (Edin.), "Investigation on Potato Virus Diseases," at the Bose Institute, Calcutta; Dr. P. T. Rao, D.Sc. (Waltair), "Complex Molecular Spectra of the Transition Groups of Elements (in the Near-Infrared and the Visible)," at the Andhra University, Waltair.