earth is altogether eruptive and its features are logical results of the ordinary processes. The notion of an original crust is discounted and material divergences from current ideas are indicated.

Lightning and the development of its discharge: B. F. J. SCHONLAND (by invitation). An account is given of further photographic studies of the lightning discharge, using an improved form of Boys camera with two fast-moving, one slow-moving and one fixed lens. It has been shown previously that the majority of lightning strokes examined were double and consisted of a downward-moving dart-like leader-stroke, followed immediately upon arrival at the ground by a more intense flame-like upward-moving main stroke. Examination of 75 flashes by improved methods has now shown that this combination of leader and main stroke is general. The leader which blazes the trail for the first of a series of lightning strokes along the same path is, however, of a different character to the others, for the luminous track does not pass rapidly downward but pauses on its way after completing each new length of 50–100 meters (stepped leaders). These stepped leaders are found to split on their way, blazing downwardly directed branches, which are subsequently more brilliantly illuminated by the upward-moving main discharge. In a number of cases the most brilliant part of the subsequent discharge is not from ground to cloud but from ground to one or more of the branches. It is suggested that the leader stroke carries down into the air as an electron avalanche the major portion of the cloud charge. The stepped leaders pause for times of the order of 10^{-4} second, and would thus give rise to radiation on a wave-length of about 30 kilometers, an effect which may play some part in the formation of the ripple in atmospherics. The work was carried out in conjunction with H. Collens and D. J. Malan and under the auspices of the South African Institute of Electrical Engineers.

Aluminizing process for coating telescope mirrors: JOHN STRONG (introduced by R. A. Millikan). A steel bell jar 40″ in diameter is evacuated by apiezon oil diffusion pumps and a Hypervac pump to 10^{-4} mm of mercury pressure. Aluminum is distilled from twelve tungsten coils to form a uniform film 1/10 μ in thickness on the surface of the telescope mirror. The mirror surface is made clean for the coating process by an electrical discharge as the bell jar is being evacuated. The evaporated aluminum coat is immune to tarnish, adheres tenaciously to the glass and is not easily scratched once the oxide film, which forms on it, is established. The reflectivity is 89 per cent. in the visible, dropping gradually to 80 per cent. at 2500 Å. Measurements at Lick Observatory show the reflectivity, for photographic light exceeds silver by approximately 50 per cent. Stellar spectra to 3000 Å have been obtained.

Pure rotation spectrum of the HCl flame: JOHN STRONG (introduced by R. A. Millikan). Pure rotation lines for $j = 17$ to 33 of the emission spectrum of the HCl flame are measured with a KBr prism. The following empirical formulae are determined to represent two series of lines measured corresponding to pure rotation in the two lowest oscillation states:

$$N = 0, \qquad \nu = 20.9\ j - .00185\ j^3$$
$$N = 1, \qquad \nu = 20.2\ j - .00163\ j^3$$

The linear coefficients agree satisfactorily with values calculated from the empirical oscillation-rotation formula. Theoretically the two cubic coefficients should be equal. High values of j allow considerable accuracy to be ascribed to these cubic coefficients, so the discrepancy is not regarded as accountable by experimental error.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE PLACE OF PHONOPHOTOGRAPHY IN THE STUDY OF PRIMITIVE MUSIC

THE purpose of this note is to illustrate an up-to-date method of recording, transcribing and interpreting primitive music.[1] The relatively original features are the use of the graphic method of phonophotography and the transcription of songs in the pattern score. The original materials may be collected by the improved phonographic field equipment and, in increasing amount, by the newer methods of sound film production. In some instances the phonophotographic apparatus itself can be taken into the field. In the laboratory the phonophotograms will be made from the sound recordings. From a single playing before the microphone three groups of records are made: First, a re-recording of the song on hard disks for auditory reference; second, a phonophotographic record of pitch, intensity and time; and, third, an oscillogram for harmonic analysis to determine tone quality.

Fig. 1 presents in pattern score a song by a woman singer of the Sioux tribe, who exhibited at the Century of Progress. The record was taken to the Iowa Laboratory for graphic analysis through the kindness of Miss Frances Densmore, who in turn acknowledges her obligations to Dr. George Herzog for recording by the Fairchild aluminum disk recorder. The present note deals only with the technique of graphical recording; the musical interpretation of this particular record is left to Miss Densmore and indeed to any student of primitive music who will give the time to draw upon the resources here presented when dealing with any specific issue.

In this score the upper curve of each section represents pitch and the lower is a graph of intensity,

[1] See Metfessel's "Phonophotography in Folk Music," University of North Carolina Press, 1928, and various authors, "Studies in the Psychology of Music," Vol. I, University of Iowa, 1932.

both on a time scale. Pitch is indicated at the left by identification of certain lines in the musical scale and intensity by numbers denoting decibels. Each horizontal space represents a semi-tone for pitch and four decibels for intensity, zero being taken arbitrarily as approximately the level of the weakest

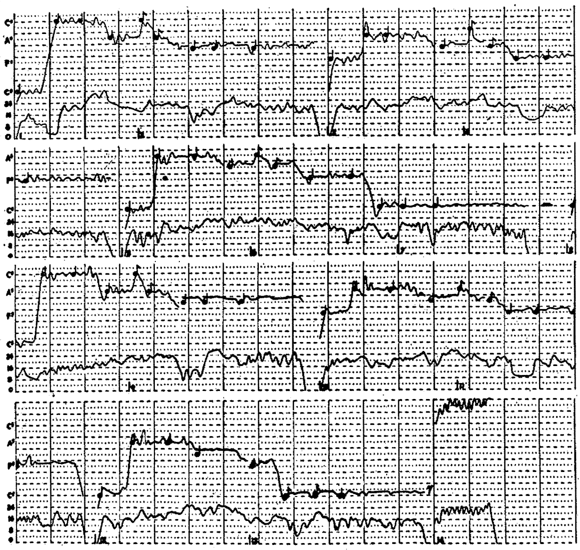

FIG. 1

tone in the song. The vertical bars denote seconds, which are subdivided into tenths of a second by dashes and spaces. Each tone is represented by a graph tracing the tone movement in exact detail. The conventional notation is interpolated merely as a guide to persons not accustomed to reading this type of record, and illustrates to some extent the limitations of conventional musical notation.

The pitch graph is a faithful record of all the characteristics of pitch intonation in the entire song. It gives the melody and reveals all types of pitch variation in the sustained tones, transitions, attacks and releases. It measures tonal intervals and shows what relation the singing has to scale systems. It shows the character of the phrasing. One is struck at once with the futility of trying to convey an adequate description of the pitch performance in terms of the conventional musical notation as based on auditory transcription. The presence of a fairly normal and beautiful vibrato is confirmed and quantified as to extent and rate. Other tonal ornaments allied to those discussed by Metfessel in Negro singing are shown in certain characteristic flights and dips. Apart from irregularity and lack of rigidity, the deviations from recognized tonal intervals are matters of great interest. The whole tonal movement reveals the characteristic abandon in the legato style which calls for interpretation into musical significance.

The intervention of the phonograph record between the original singer and the photograph in this case introduces certain well-recognized errors, but relatively the dynamic relationships are recorded significantly. Here one sees all the varieties of increase and decrease in loudness from moment to moment, the divisions of measure, meter and rhythm, numerous devices for ornamentation and, of course, many manifest faults. It is of great value to be able to see the tonal, dynamic and temporal aspects in the same picture in an integrated situation.

In the pattern score we have a source of information from which to determine the tempo, time variations, measure formation, rhythm and phrasing of the song. Since pitch and intensity are plotted against time, the interrelationships can be studied more easily. Finer time measurements can be made from the original phonophotogram, which is on a larger scale.

The fourth factor, timbre, is of such vast intricacy that it does not lend itself to complete record in the pattern score. One may, however, select any number of samples at strategic points in the oscillogram and show the spectrum which results from harmonic analysis of the form of the wave. Of course a true sound spectrum can be made only from the original source of sound. Where an adequate oscillogram is obtainable, it is now clearly possible to preserve and describe the exact quality of the tone in quantitative terms. For some less exacting studies, harmonic analysis of sound waves from extra high-grade recordings will be profitable.

Where words are present, a phonetic transcription should, of course, be inserted into the pattern score. This song had no discrete words. Field notes and other accessory data should be supplied according to current methods of musical anthropology.

Thus we may have in these four elements of tone an adequate record in permanent objective form. But, it is asked, what of the feeling, the interpretation, the esthetic appeal and all that is precious to the musician? The answer is that it is all there, because everything that is conveyed from the singer to the listener, whether it be information, emotion or a drive to action, is expressed through these four media in the objective record and in none other. We have not yet felt the full impact of the principle that in the sound wave the intangibles of music are physically tangible.

It is possible that many of the wax recordings stored in the ethnological archives can be redeemed for further value by the principles herein discussed. Many of them are fairly adequate with respect to pitch and time; intensity and tone quality factors would have to be omitted from such study.

With the improved techniques of field recording and of laboratory study it is of course desirable that in all future collecting only adequate and permanent recordings should be made. The limitations of transcription by hearing have been pointed out clearly by the phonophotographic analysis.

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SPECIAL ARTICLES

A LETHAL DWARF MUTATION IN THE RABBIT WITH STIGMATA OF ENDOCRINE ABNORMALITY

RECESSIVE dwarf mutations in the guinea pig and in the mouse have been described by Sollas[1] and by Snell,[2] respectively. Both of these mutants are viable, and carriers of the dwarf genes appear to be normal. The skeletal changes in the guinea pig suggest an achondroplastic dwarf, while according to Smith and MacDowell[3] the dwarf character in the mouse is due to a hereditary deficiency of the growth-promoting hormone of the pituitary.

Abnormally small or dwarf-like individuals are of frequent occurrence in the rabbit as familial characters but, as a rule, affected animals show no serious impairment of vitality or any other decided abnormality. A dwarf mutation has been encountered, however, among the progeny of a Polish rabbit which is of interest from the point of view of size inheritance, on the one hand, and the occurrence of pathological conditions in animals possessing the dwarf gene, on the other. This mutation appeared in the course of experiments which were being carried out for other purposes and the nature of the abnormality has not been determined with certainty, but the evidence obtained so far indicates that the condition is of endocrine and probably of pituitary origin.

The original male transmitting the dwarf gene has been mated with related and unrelated Polish females and with numerous unrelated females of various breeds. From the F_1 progeny thus obtained, F_2 and back-cross litters have been produced.

An analysis of birth weights shows that the F_1 progeny is divisible into a large and a small class of equal numbers (55 small, 56 large). The actual weights of these animals are influenced by the relative weights of parental stocks, but in general the ratio of the small to the large class is 4: 5. In two instances, typical dwarfs occurred in F_1 litters. The F_2 progeny contains individuals of three classes with a birth weight ratio of approximately 1: 2: 3. The same result is obtained when certain F_1 females are back-crossed to the original male parent, while with other females the litters are of the F_1 type. The actual weights obtained for 56 young derived from parents both of which were known to produce dwarfs were 13.66, 31.55 and 46.86 grams. The number in each class was 15, 26 and 15, respectively. A slight excess in the weights for classes 2 and 3 may be attributed to the fact that animals of these classes are frequently fed before weights can be obtained, while those of class 1 are not. No correction is made in the values given.

Individuals of class 1 are non-viable dwarfs. As far as we have been able to determine by test matings, those of class 2 are transmitters of the dwarf gene, while those of class 3 are homozygous normals. The F_1 progeny is composed of animals corresponding genetically with those of classes 2 and 3.

The dwarfs of this stock are born alive and occasionally they are capable of nursing, but so far, none of them has lived longer than a few days. They are delicately formed and to outward appearance are fully developed except for the bones of the calvarium, which, as a rule, are incompletely calcified.

Other classes of young are apparently normal at birth, but they are subject to numerous abnormalities in early life and to a peculiar process of deterioration after full sexual maturity has been attained. The most evident of the early abnormalities is an affection of the bones, which is characterized by the resorption of calcium with the production of cranial defects, spontaneous fractures of the long bones and deformities due to bending, which indicate increased fragility, on the one hand, and softening or osteomalacia, on the other. This condition develops during the first few weeks of life. At the onset, animals of this type are well nourished, or even fat and pudgy, but in time growth is diminished or completely arrested and they are extremely sluggish. Death is apt to occur at this stage. Vitamin treatment is of little or no avail, but rapid improvement follows fostering and there is some recent evidence that irradiation with the Mazda CX lamp is beneficial. Animals that recover are active and vigorous, but they present a dwarfed or stunted appearance; they are, for a time, pot-bellied and their legs are deformed and shortened. After maturity has been reached, a secondary deterioration occurs in many animals which is characterized by loss of weight (20.0 to 30.0 per cent.), softening and erosion of the teeth and reproductive disorders.

These peculiarities appear to be limited to carriers of the dwarf gene or are more pronounced in animals of this class than in their normal litter mates, but the

[1] I. B. J. Sollas, *Rep. Evol. Com. Royal Soc.*, 5: 51, 1909.
[2] G. D. Snell, *Proc. Nat. Acad. Sci.*, 15: 733, 1929.
[3] P. E. Smith and E. C. MacDowell, *Anat. Rec.*, 50: 85, 1931.