(35) A communication from Dr. J. C. Merriam regarding adult education was presented. After discussion a committee was appointed to consider the subject and to make a survey of possibilities for the A. A. A. S. to develop this work. The committee appointed is as follows: Harlow Shapley, *chairman,* W. H. Howell, C. C. Little, John C. Merriam and Wm. F. Ogburn. It was suggested that this committee consider the manner of cooperating with other organizations and co-opt other members or if desired form subcommittees to study special topics in order to report in October.

HENRY B. WARD,
Permanent Secretary

THE NATIONAL ACADEMY OF SCIENCES. IV

The velocity-distance relation for isolated extra-galactic nebulae: EDWIN HUBBLE and MILTON L. HUMASON. The velocity-distance relation, log $v = 0.2m + 0.706$, derived from 85 isolated nebulae, parallels that derived from clusters, but is displaced toward the brighter side by about one magnitude. The displacement is interpreted as an effect of selecting the nebulae on the basis of apparent magnitude. Since the luminosity function approximates a normal error curve with a maximum at M_o and the density function is constant, the frequency distribution of M for a given *m* will be another normal error curve with the same dispersion but with the maximum displaced by $M_o - \overline{M} = 1.386^2$. The observed displacement represents a dispersion of the order of 0.85 mag., in close agreement with observed dispersion, 0.86 mag., of the residuals. Isolated nebulae and cluster members give the same velocity-distance relation and hence are strictly comparable objects. M_o may be estimated from the Virgo cluster, where stars are found in some of the nebulae. The data as yet indicate no significant revision of the value previously derived, $M_o = -13.8$.

Loudness and pitch of musical tones and their relation to the intensity and frequency: H. FLETCHER (introduced by F. B. Jewett). Loudness and pitch are psychological terms which are used to describe sensations produced when certain types of waves operate upon the hearing mechanism. Intensity and frequency are the corresponding terms to describe the physical quantities power transferred per unit area and vibrations per second executed by the sound wave. The relation between these psychological and physical aspects of a musical tone has been investigated using a group of typical listeners. Precise scales were invented and used for representing the sensations of loudness and pitch. In comparing loudness a pure tone having a frequency of 1,000 cycles per second and with intensity variable throughout the audible range was used as a reference tone. In comparing pitch, a pure tone having a constant loudness and with frequency variable throughout the audible range was used as a reference tone. Typical results follow: A 50-cycle tone with an intensity which is 10,000 times that at the threshold of hearing produces the same loudness as a 1,000 cycle tone with an intensity which is 1,000,000,000 times its threshold value. The intensity of a complex tone with ten components all equal in intensity but different in frequency is ten times that of each component, as is well known. On the other hand, the loudness of one such complex tone with frequencies which are harmonics of 500 cycles per second was found to be equal to that of the 1,000 cycle component raised one thousand times rather than ten times in intensity. An observer's location of the pitch was found to depend upon the intensity as well as the frequency. For example, the pitch of a 200-cycle tone was located at a position which was as much as one quarter of an octave lower at the very high intensities than at the low intensities. For pure tones having frequencies near 2,000 or 3,000 cycles per second, no difference of pitch was observed as the intensity was changed. Similar small pitch changes were observed with complex tones. Some very large changes were observed with particular changes in the components. For example, the pitch of a complex tone having four components of equal intensity, but with frequencies of 400, 600, 800 and 1,000 cycles per second was perceived as that corresponding to a 200-cycle tone. If to this complex tone, three additional components having frequencies 500, 700 and 900 cycles per second, are added, then the pitch will be perceived as an octave lower or that corresponding to a 100-cycle tone.

The realm of the nebulae: EDWIN HUBBLE. The observable region—the region of space that can be explored with existing telescopes—is a vast sphere through which a hundred million nebulae are scattered at average intervals of the order of a million light years. Each nebula is a stellar system comparable with our own system of the Milky Way. If the observable region is a fair sample, we may hope to infer the nature of the universe from the observed characteristics of the sample. Two general characteristics have been established in the past five years. The large scale distribution of nebulae is uniform, since counts of nebulae behave as random samples of a homogeneous population. Light from the nebulae is reddened in direct proportion to the distance it has traveled. These data, together with the general laws of nature, permit certain inferences concerning the universe which are embodied in the current theories of cosmology.

African rift valleys: BAILEY WILLIS. African rift valleys have been interpreted as cracks due to tension produced by collapse of the hypothetical Gondwana Continent. They are found to be effects of unequal elevation, combined with local compression with or without extrusion of lavas. Theoretical discussion involves problems of general application to elevation subsidence and mountain building.

Isostasy and the eruptive crust: BAILEY WILLIS. Isostasy and eruptive crust are related as effect and cause. The argument is that the existing crust of the 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.

[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.

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,