work of Abbé le Maître and of Eddington, the problem may be more complicated than was believed previously. In fact, the universe may, perhaps, not at all possess a constant world curvature; and it must be admitted that the preponderantly positive radial velocities of the spiral nebulae are most simply explained by assuming the whole universe to expand, and to have nothing to do with the de Sitter-Doppler effect.

On the whole, the subject of the curvature of space is one in steady progress, the present state of which does not encourage to any display of orthodox convictions, but which may become of considerably more cosmologic importance in the near future.

SVEIN ROSSELAND
OSLO UNIVERSITY OBSERVATORY

Determination of Orbits of Comets and Asteroids. By RUSSELL TRACY CRAWFORD. xi + 233 pp. McGraw-Hill Book Company, 1930.

A TEXT-BOOK designed for a college course of one semester to provide an introduction to the subject of orbit determination. The following subdivision of the book could be made: (*a*) Introductory chapters treating the motion of a body about the sun as attracting center, also including the subject of ephemeris computation; (*b*) Leuschner's method of orbit determination; (*c*) Merton's modification of the Gaussian method of orbit determination. Completely worked out examples and summaries of formulas for both methods and fourteen auxiliary tables are added.

As the author states in his preface, this work is different from other treatises on orbit computation. It is not intended to be complete, and does not, for instance, include the mathematical development of precession, nutation, special perturbations or least squares. "The definitive orbit" is very briefly treated, but logically, considering the fact that the book treats undisturbed orbits only.

Notwithstanding limitations set by the scope of the book, it is complete enough to be a very useful reference book. Those interested in more intricate problems, mainly of theoretical importance, which could not be fully treated, will find many helpful references to original publications.

This is the first time that a coherent presentation of Leuschner's method is published, after the original publication in Vol. VII of the Lick Observatory Publications. (Buchholz-Klinkerfues, 1912, gave little more than a set of formulas and examples.) Especially because many treatises on orbit computation entirely disregard the existence of other methods than the Gaussian we could have been satisfied with a book presenting Leuschner's method only. The fact that two methods, one representing the Laplacian and the other representing the Gaussian method, are given testifies to the broad attitude taken by Leuschner and his followers.

That Merton's development of the Gaussian method is chosen is not surprising. It has done away with a number of complications mainly due to the former necessity of adapting all formulas to logarithmic computation. The two methods offered are undoubtedly distinguished by theoretical clearness and adaptation to practical needs.

It would have been impossible within the scope of the book to include a critical comparison of methods of orbit computation. This is left to the student. The field which this book covers is very large, so that a selection was necessary. The author has made an admirable choice guided by his expert knowledge of the subject and experience in teaching it.

The book is beautifully printed; one can only wish that the subdivision of the chapters had been made more uniform and more distinct. The generous size of the pages (10 x 7 inches) has contributed much to its fine appearance, as many long formulas had to be included. The book is dedicated to Professor A. O. Leuschner, "a most stimulating teacher and inspiring director."

DIRK BROUWER
YALE UNIVERSITY OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN OBJECTIVE METHOD OF EVALUATING MUSICAL PERFORMANCE

IN the psychological laboratory of the University of Iowa we have developed instruments which enable us to record actual singing and playing accurately and quickly. This is done mainly with the strobophotograph camera designed by Professor Milton Metfessel[1] and recently improved by Tiffin and Reger. It virtually graphs two of the four elements of musical performance, namely, pitch and time. The other two elements, intensity and timbre, are not recorded.

A stroboscopic disk runs between the film and a neon lamp. The lamp flashes in frequency with the sound wave, and the film, moving past at a constant speed, registers a continuous picture of the stroboscopic effect. The stroboscope registers in terms of tenths of a tone but finer readings may be made in proportion to the steadiness of the tone.

The object of this note is to illustrate how this

[1] *Jr. Gen. Psychol.*, 2: 135–139, 1929.

method may be used in evaluating the singing or playing of an amateur as compared with a professional singer; or, for that matter, any comparison of two singers or players.

Figs. 1 and 2 are records in the scientific musical notation called the "pattern score" showing the rendition of "The Last Rose of Summer" by an amateur whom we shall call "Helen" and by Frances Alda, respectively. Assuming that Alda is a good representative of an artistic singer and that Helen is a promising amateur whose performance we wish to compare with a recognized artist, we may compare in detail the performance of the amateur with the performance of the recognized artist.

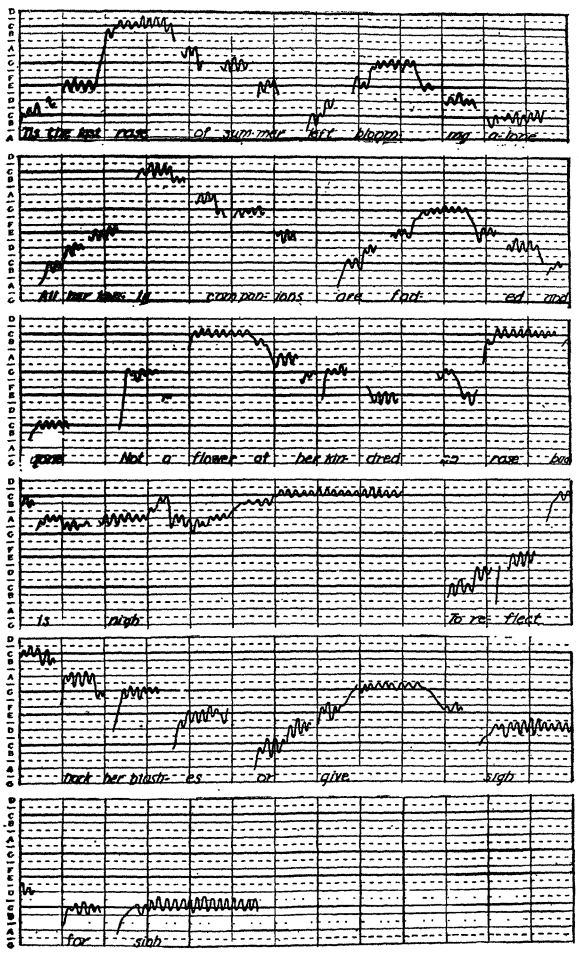

FIG. 1. "The Last Rose of Summer" as sung by an amateur "Helen."

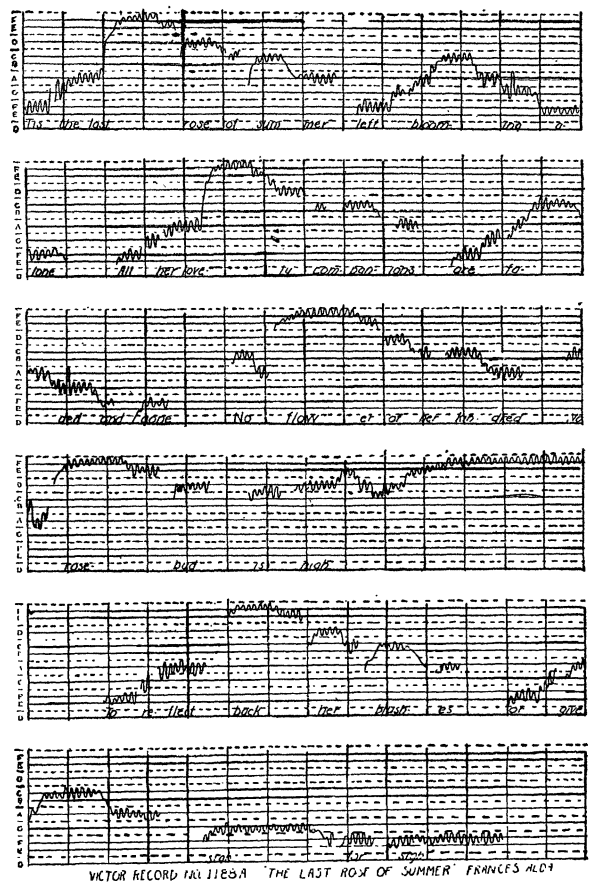

FIG. 2. "The Last Rose of Summer" as sung by Frances Alda.

Intonation is indicated in minute detail in the form of a graph for each note, showing in exact detail what was actually sung, as to pitch and time. The vertical lines divide the staff into seconds; the notes are indicated in the margin at the left; the solid lines indicate the white keys and the broken lines the black keys. The oscillations in the graph for each note show the character and extent of the vibrato.

One is struck with the great liberty that the artist takes with the conventional musical notes. Presumably the beauty in the rendition lies in the artistic deviation from the conventional notes, both as to pitch and time. It may be noted that these deviations from the true intonation are seldom heard in their true extent, even by the ear of good musicians, because we have the habit of apperceiving music in terms of the conventional notation. At any rate one who is not familiar with the objective analysis of singing, such as here given, is surprised to find the artist deviating so greatly from the musical notation.

Now to evaluate our amateur singer we may at once make comparison of the relative duration and intonation of each tone throughout the selection, and the division of emphasis. We may then consider each note in detail: (1) as to the mode of attack; (2) as to the mode of release and transition; (3) as

to duration; (4) as to the mean pitch, the pitch actually heard tending to be approximately 6 per cent. of the extent of the vibrato below the center of the oscillation; (5) the vibrato, considering such facts as number of pulsations per second, the amplitude in pitch (each horizontal space representing a semitone), and regularity of the vibrato, and (6) the occurrence of mordents, as on the last syllable of "blooming" and the last syllable of "faded" by Alda. Numerous measures of subordinate elements for each of these factors may be made. Of special interest is the mode of glide, particularly within the tone itself, as on the words "the last" by Alda.

Here a single artist is taken as an example of a good singer. There are, of course, great differences among good artists; multiplying of illustrations brings out these features. We here simply wish to illustrate the principle.

In interpreting the relative performance of the two singers we must fall back upon a gradually accumulating series of norms which we are now building up for all these factors. For example, Helen's vibrato, which averages about five pulsations per second, is somewhat too slow as rated by our norms for artists. Alda's rate of about seven pulsations per second is approximately the most favored rate. On the other hand, the amplitude of Helen's vibrato is not quite as large as Alda's, or as the norms for artistic singers in general. This may or may not be in her favor. One of the writers is of the opinion that it is decidedly in her favor because the more subdued the vibrato the more pleasing it is to him.

But such subjective differences of opinion may now be gradually eliminated by two different processes: first, by measuring agreement in practice among the great artists; and second, by determining the best achievement of such artists under experimental control and submitting these to experimental analysis and evaluation from the point of view of experimental esthetics. This procedure of giving recognized artists the opportunity of perfecting performance with the aid of measuring instruments under fractionated procedure is the avenue through which we shall ultimately establish norms of artistic achievement.

When the other two factors, intensity and timbre, are recorded with the camera and added to our scientific musical score of performance, we shall have a comprehensive objective basis for the comparison of musicians and for the detailed quantitative account of musical value.

CARL E. SEASHORE,
JOSEPH TIFFIN

UNIVERSITY OF IOWA

SPECIAL ARTICLES

THE TREATMENT OF PATIENTS WITH ADDISON'S DISEASE WITH THE "CORTICAL HORMONE" OF SWINGLE AND PFIFFNER

THE preparation of an aqueous extract of the suprarenal cortex which would maintain the life of bilaterally suprarenalectomized cats indefinitely was announced by Swingle and Pfiffner in a brief article published in SCIENCE of March 21, 1930. Subsequently they have reported that by the administration of this extract they were able not only to revive comatose animals, on the verge of death from suprarenal insufficiency, but also to restore them to a normal condition and to keep them in perfect health by daily injections.

The significance of such an announcement and the interest aroused by the possibility of using this extract in clinical medicine are obvious. An extensive experience in the use of the so-called Muirhead regimen in cases of Addison's disease has convinced us of the futility of ordinary therapeutic measures in combating the crises of acute suprarenal insufficiency which develop in the course of this disease and of the great need for a more active cortical preparation which can be administered either hypodermically or intravenously. This point was further emphasized by a patient with Addison's disease who was brought to the hospital in a state of complete collapse, May 31, 1930. The outlook seemed hopeless under ordinary conditions, but as a last resort a telegram was sent to Drs. Swingle and Pfiffner and they forwarded a supply of cortical extract by air mail. The patient, who was in a state of typical collapse, was restored to activity within two to three days. A summary of the clinical history in this case follows:

The patient was a farmer, aged thirty-nine years, and first came to the clinic in January, 1930. He had had pleurisy with effusion eleven years previously and symptoms of Addison's disease had been present for eight months. He was in a critical state when admitted; he was in collapse, the systolic blood pressure was 78 mm of mercury, and the blood urea 48 mg for each 100 cc. Treatment was given with solutions of sodium chloride and glucose intravenously, and the Muirhead regimen was instituted. The patient improved slowly; he was dismissed from the hospital thirty-nine days after admission.

Progress at home on the Muirhead regimen was satisfactory for a while, but the patient was brought back to the clinic in a state of collapse, May 31. Treatment