a complete corps of efficient lecturers who could answer the call to some local organization.

There are many individuals who are looking for a field in which they can utilize their executive powers in a worthy way. There are many wealthy people who are ready and even anxious to donate funds to a worthy cause. We believe a no more worthy cause exists than the one just suggested.

Much work has already been accomplished by organization such as the Y. M. C. A. to encourage right living among young men, but little of it touches the group of busy individuals who are the victims as well as the causes of the Period of Retrogression.

C. H. FORSYTH

ANN ARBOR, MICH.

SPECIAL ARTICLES

A METHOD OF PLOTTING THE INFLECTIONS OF THE VOICE

SOME time ago, while the writer was engaged in the study of the "tones" of certain oriental languages, it became desirable to represent visually the tonal movements or figures executed by the voice in actual speech. Records of native speech were taken by the Rousselot apparatus, and the wave-lengths in each tracing were measured throughout, resulting in a series of numbers for each utterance—which series we may for the moment suppose as included within the compass of two octaves, from 10 to 40 of our scheme.

In default of any record of previous attempts of this kind, the following scheme was first tried as the most obvious and simple. Beginning at the top, the unit lines of the coordinate paper were numbered in succession downward from 10 to 40. Then beginning at the left-hand margin the measured numbers from the record were plotted in order, each upon its numbered line, but each advanced beyond its predecessor by a constant interval chosen after experiment as best suited to bring out the features of the voice-inflection. A continuous line drawn through the series of plotted points would then represent the movement of voice as regards pitch. Finally the whole was brought into relation with concert pitch by measuring the wave-length of the record of a C-fork and marking its place among the numbered lines, and computing the positions of the other notes of the scale according to the well-known ratios of the diatonic scale.

The results seemed convincing; but a study of them revealed a certain distortion of vertical values similar in kind to the horizontal distortion of Mercator's maps. This was due to the fact that the number-intervals were equally spaced, whereas to our thought and visual imagination the semitone intervals are equal. The first step toward remedying the difficulty was obvious and easy. The letters of the twelve semitones took the places of the integers on the unit-lines of the chart. The next step—to find the new places of these integers—was not so easy. After some fumbling and groping the following points became clear.

1. Each semitone of the series brings with it to its new place the same numerical value which it had in its former position as a definite term of a geometrical progression of twenty-four terms between 10 and 40, with $\sqrt[2]{2}$ for the common ratio. In Table I. below are given these values for the upper octave. Those for the lower octave are simply twice these. These numbers were entered on the chart against their respective semitones.

2. The integral numbers must next be assigned to their proper stations within this decimal series. Indeed 10, 20 and 40 already appear in that series, and so are assigned to position; while 15 and 30 are so close to semitone positions as to be practically coincident with them. A rough determination of the other positions might be made by the method of proportional parts, but the only real determination is by solving the equation of the geometrical progression just described. That equation is $y = a^x$, in which y and x are variables, and a is constant, namely the common ratio $\sqrt[12]{2}$. The values of y are the integral numbers from 10 to 40. By applying these values in succession to the equation, the corresponding values of x are obtained, that is the

vertical distance from line 10 to the level of each integer. These ordinates are given in Table II. below.

Another element of distortion, though very slight, was found in the assumption of equal spacing for the horizontal intervals between successive points in the plot. The spaces *ought* to vary somewhat according to the levels of pitch. It was, however, some time before it became clear that the single measurement determined the position of the point on *both* coordinates—on the vertical one as pitch, and on the horizontal one as time-elapsed between successive wave-crests in the record.

So amended, the scheme seems perfect. Nevertheless a suggestion or two may save much time and trouble to one who may have occasion to use it.

It is neither necessary nor desirable to measure separately every wave-length of the record. It is quite as well to measure them in groups of five together and take the average for plotting, if only one measure separately the very first wave and the last, so as to make sure of the pitch at those points. Similarly the intervals for the horizontal spacing need not be the very ones indicated by the measured numbers, but rather some constant fraction of them, such as will better bring out the features of the curve.

All the numbers concerned in the scheme are merely ratios setting forth the relationships between the various elements of it within the compass of two octaves of pitch, which is quite sufficient to cover the range of any voice in ordinary speech. The scheme may therefore be used just as it stands if the measurements do not exceed its limits. If they do, the whole system may be raised an octave by the simple device of dividing the integral numbers throughout by 2, or lowered an octave by multiplying them by 2. Or it may be raised a fourth by multiplying them by 0.7, or lowered a fourth by multiplying them by 1.5—taking pains however in these last cases to shift the semitone letters correspondingly.

Since the semitone intervals are all equal, the C which represents concert pitch may be placed anywhere in the field where its measured wave-length indicates. All the other semitone letters then will take their places at the same constant distances as in the scheme described.

TABLE I

Ratios of the Tempered Scale

C	10
B	10.60
A♯	11.23
A	11.89
G♯	12.60
G	13.35
F♯	14.14
F	14.98
E	15.87
D♯	16.81
D	17.81
C♯	18.87
C	20

TABLE II

Ordinates of the Number Series

Number	Distance	Number	Distance
10	000	26	16.54
11	165	27	17.19
12	316	28	17.82
13	454	29	18.43
14	582	30	19.02
15	702	31	19.58
16	814	32	20.14
17	918	33	20.67
18	1,017	34	21.19
19	1,111	35	21.69
20	1,200	36	22.17
21	1,284	37	22.65
22	1,365	38	23.11
23	1,442	39	23.56
24	1,515	40	24.00
25	1,586		

CORNELIUS BEACH BRADLEY
UNIVERSITY OF CALIFORNIA

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 557th regular meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, May 20, 1916, called to order by President Hay at 8 P.M., with 30 persons present.

On recommendation of the council, James L. Peters was elected to active membership.

The president announced that the council of the society had voted to adopt the custom of medical societies and of many other scientific societies limiting the members to speak but once during the